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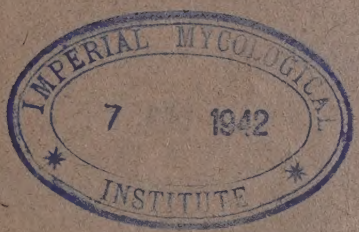

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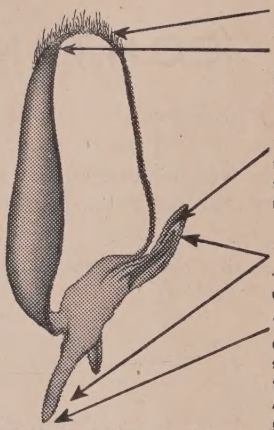

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VOL. 8, No. 1 MARCH, 1942

Rural Economics

By

A. R. CALLAGHAN, H. G. ANDREWARTHA and K. WOODROFFE.

The authors were appointed a sub-committee by the South Australian branch of the Institute to prepare a statement on Rural Economics as a basis for discussion at a branch general meeting. This article represents the final outcome of the report and subsequent discussions.

The need for a close study of rural economics is generally conceded, and is being seriously considered by members of the Australian Institute of Agricultural Science in all parts of Australia. When it comes to the clear definition of requirements, and the methods to be adopted, however, it is apparent that the issues are by no means clear, and the opinions expressed so far are widely divergent. This may well be due to differences in emphasis on particular aspects of the subject. Emphasis is placed by some, for instance, on the national aspects of agricultural economics as a basis of advice to governments, by others on economics as it directly concerns farm management and advice to the farmers themselves. It is considered that some attempt should be made to describe in general terms the economic approach to rural problems. This is such an attempt, and broad as the definition has necessarily been, it is hoped that it may at least prove to be a constructive contribution to the thought, the enthusiasm and the hopes of Institute members generally.

So far, in Australia, agricultural research, education and extension have been directed almost exclusively to the technique of production. Relative ease of production, lack of severe competition and comparatively assured markets until the depression years between 1930 and 1933 were the chief factors responsible for a complacent attitude throughout Australia to the study and application of rural economics. Since then many factors have increased the intensity of world competition, former markets have sensibly narrowed, and the deficiencies and weaknesses in the economy of Australian agriculture have been disclosed. As a result, general interest in problems associated with the economics of rural production has developed.

SURVEY OF EXISTING ORGANISATIONS.

The field of rural economics has not been wholly neglected in Australia, although no comprehensive or co-ordinated studies have been made that compare with those

of the U.S.A. Bureau of Agricultural Economics, or with those of other Empire countries, notably the United Kingdom, Canada, South Africa, New Zealand or India.

The State Departments of Agriculture and the Commonwealth Department of Commerce, constantly faced with problems of marketing in recent years, have carried their investigations into this domain. Both New South Wales and Queensland have organisations dealing with marketing. In addition, the New South Wales Department of Agriculture has recently established a Division of Agricultural Economics.

The banks, and particularly the State banks specifically created to provide rural credits, might be expected to have the constant services of a trained economist. The Rural Bank of New South Wales has established such a service, the work of which has been favourably recognised.

The Queensland Bureau of Industry has the organisation and direction for working upon rural as well as other economic problems. At present this bureau is concerned chiefly with non-rural matters and does not possess the necessary personnel to undertake purely rural economic investigations.

The University Faculties of Agriculture have, for the most part, failed to anticipate the need for trained rural economists. The Melbourne Faculty, for the past 15 years, has included some rural economics in the agricultural course and the School has, from time to time, made valuable contributions, although the field of work has been limited through lack of personnel. At present rural sociological surveys are being made by the Melbourne School. The Western Australian Faculty has also shown interest in the subject in recent years and has undertaken certain surveys bearing on the economics of production. In the Sydney Faculty a special course in rural economics has been given since 1933, a general course in economics having been given since 1928. General plans for the training of rural economists are under consideration by the Universities of Australia.

The agricultural colleges included farm book-keeping in their curricula, and in most cases give some instruction in rural economics; this applies especially to Hawkesbury and to Roseworthy, where the object primarily is to meet the needs of prospective rural producers.

The Council for Scientific and Industrial Research has not attempted to explore the field of economics. Recommendations and findings in rural economic matters would be less exact, more controversial, and more subject to political interpretation, compared with those at present made by the Council in applied natural sciences. The fact that the corresponding organisation in New Zealand has already embarked on economic studies is, however, of relevant significance.

The truth is that few detailed economic studies of specifically rural character have been carried out in Australia, nor have the various oragnisations attempted an advisory service in economics. The work would have necessitated special organisation and personnel, but it is rather astonishing that until recently not one of the many bodies has specialised in this way.

The present wave of interest augurs well for the future. If developments in the various States and under the ægis of various organisations are soundly directed to avoid unnecessary duplication, there should evolve a service capable of rendering advice upon rural economics to the community, as effective as the present service in the technique of production.

OUTLINE OF AN ECONOMIC APPROACH.

In preparing the following statement questions of technique and administration have been purposely excluded. An attempt has been made to outline in general terms the economic approach which may be necessary to meet the rural problems in Australia.

(1) Markets.

Reliable short and long term estimates of the character and extent of both internal and external markets are the essential pre-requisites to sound rural production and development.

The economic forces determining the scope and character of markets will be controlled pre-eminently by international developments and settlements and international policy will, as it has done in the past, largely determine national economic policies.

Extensive world trends must influence the future of markets. Apposite examples are such well recognised factors as the influence of technological advances, trends in population, changes in the food consumption habit of people, the growth, dissemination and adoption of new knowledge of nutrition and the development of substitutes.

Many problems exist with regard to the relation of external markets to local markets, not the least important of which is the effect of home consumption price schemes on the efficiency and trend of particular rural industries. The effects of the growth of Australian industry and the production of secondary goods call for specific attention in so far as both internal and external markets are concerned. The production of secondary goods in sufficient quantity to satisfy or exceed local demands raises important questions of policy.

Further to the definition of the scope, character and potentialities of markets, their exploitation is based upon the competitive efficiency of Australian production ; this represents a direct challenge to productive efficiency in Australia.

In this field it is obvious that general economic theory in the widest sense is involved, as the whole economic framework must ultimately affect both external and internal markets, particularly external markets. Few, if any, of the problems of markets belong solely to the realm of rural economics, but it is of vital importance than they be studied as a specific aspect of rural economy.

(2) Rural Finance.

This embraces problems associated with agricultural credit taxation, customs and excise tariffs, bounties and subsidies.

Agricultural credit involves monetary loans and the supply of goods. Monetary credit includes investment by private contract and moneys advanced from public funds ; it may take the form either of fixed term loans or or loans on current account. Goods may be supplied on ordinary trading credits, on hire-purchase agreements, and on current trading accounts.

The nature of rural production and capital make it desirable to consider the advisability of government finance by long term loans, especially in terms of sources of finance and administrative policy. On the other hand, undue extension of government finance may interfere with the healthy circulation of private funds. Government action in the field of rural credit also includes moratorium or debt adjustment legislation and loans on specially favourable terms (Advances to Settlers Act, etc.). The possible effects of such legislation on sources of private credit and on actual and potential beneficiaries require examination, as does also the risk of loss to the State by insufficient discrimination in extending credit.

Taxation may be direct or indirect. Direct taxation as applied specifically to primary producers is covered by land tax, local government rates and water rates. Aspects of each of these taxes which need consideration are the basis of assessment and valuation, and whether rating is uniform or progressive.

The fact that certain commodities are almost wholly purchased by primary producers renders it necessary to see that by means of indirect taxation, such as sales tax, etc., the primary producer is not penalised in comparison with other citizens.

Customs and excise tariffs are adopted to secure revenue, protection, or both. It is important to consider the conflict between primary and secondary industries in relation to the tolerable limit and the incidence of the load introduced by these imposts. The tendency to offer wage earners a benefit corresponding to the benefit accruing to the manufacturer and some producers from tariffs is a secondary reaction, and the distribution of equivalent benefits to all classes of primary producers needs to be considered.

Bounties and subsidies may serve to aid development and readjustment and to counteract the effects of natural calamity ; they may be used also to implement guaranteed prices and support policies of internal quotas and export dumping. Rural education and research may be helped by government subsidy. The extent, nature and advisability of bounties and subsidies should be examined in relation to the foregoing. The problems of the degree of control over the recipients of bounty and the risk of over-stimulation of agricultural activity relate this aspect of rural economics to that of proper land use.

(3) Production and Distribution.

(*a*) *Land-use Surveys.* Land-use and potentiality surveys are one aspect of the much wider business of estimating national resources. They are an important basis for economic research in agriculture, particularly if the survey is made in detail with respect to a given area. A land-use survey records how the land is being used now ; the detail is ephemeral, but such a survey is of no great value unless estimates of potential production can be based on it. The survey should

be accompanied by a soil classification, and an investigation of the climate and the geographic position of the area with respect to markets. The survey should indicate lines for experimentation and economic investigation. The aim is to produce a plan setting out the best land use, and alternative uses in the present state of knowledge and development.

(*b*) *Farm Management.* Farm management investigation is concerned with improving net income, whereas the natural sciences are more particularly concerned with the increase of gross output. Farm management research aims at diagnosis of maladjustments and the introduction of better methods. It enables the individual to improve the organisation of his farm. Knowledge established by farm management studies is also important as an aid to the formulation of national policies.

Farm management involves the study of organisation and equipment. Projects may be general, covering many aspects of farm business, or they may concentrate on some group of related parts of farm business. Organisation, that is, the choice of enterprises and their combination, depends on markets and many factors such as soil, climate, distance from markets and soil conservation. The actual method of management of each enterprise is important, particularly the optimum utilisation of manual labour and power throughout the year. This is an essential preliminary to an intelligent criticism of existing farming systems. The study of equipment includes problems related to the optimum combination of working capital with capital invested in land and permanent improvements ; it also includes the distribution of working capital in relation to farm and enterprise units.

(*c*) *Distribution.* The distribution of primary products should be an orderly, efficient process, whereby the producer receives an equitable share of the price paid by the consumer. Investigation of present systems of handling and distributing produce may reveal that efficiency can be increased at many points. U.S.A. statistics show that in 1938 the farmer received only 40 per cent. of the price paid by the consumer. It is probable that a similar spread occurs in Australia.

Experience may indicate that the greatest economies, without drastic alteration of the present marketing system, may be obtained by standardisation of products, more efficient handling, regulation of flow to markets and an extension of cooperative marketing.

Marketing cooperatives may achieve lower costs, higher quality, better service, especially where they completely bridge the gap between producer and consumer by direct marketing. Duplication of marketing facilities and other causes of inefficiency may be eliminated by State regulated, publicly owned services operating on a bolder and wider basis than cooperatives. State encouragement to the development of secondary industries near centres of production of raw products will provide new markets and reduce freight and handling charges. Thorough investigation of existing methods and possible alternatives is the logical basis for improvements in marketing.

(4) Rural Sociology.

Since agriculture is a way of life as well as being a way of making a living, the organisation of the rural community is important both for its effect upon the technical efficiency of the farmer and for its ability to give him a satisfactory life. The technical efficiency of the farmer may be influenced by such factors as the size of farm unit, the form of land tenure, the development of cooperation in various forms, and by traditions.

In Australia the traditional form of land tenure has been justified on the grounds that it produced independence and freedom of action, and stimulated and rewarded individual initiative. Re-examination of the whole position is warranted from a sociological viewpoint to determine whether a happy and efficient rural community might not be built up around a new system with the emphasis more on service and less on rights. The size of the farm unit should be a useful study. The present system of farming land in units corresponding to the needs of one family need not necessarily be the best system. The possibilities of various forms of cooperation, including cooperation with machinery or labour, or both, cooperative marketing, land-use, and even cooperative land ownership, might be explored.

Other factors which may influence the technical efficiency and the living standards of the rural community, and which are therefore worthy of study, include education, library facilities, medical services, housing standards, and opportunities for leisure.

Rural sociology is fundamental to all problems of rural economics ; the sociological consequences of any action, or inaction, in the economic or political field, need to be carefully considered. Consequently the study of rural economics should have a strong bias towards sociology.

(5) Land Policy and Rural Development.

(*a*) *Land Policy.* A desire to preserve freedom of action, security of tenure, and the unquestioned rights of ownership, has dominated land policy in Australia. Unfortunately it has resulted in land exploitation, unsound competition for land, excessive land values, unproductive indebtedness, and, to a large extent, control by monopolies. In so far as these abuses have threatened the security of the farmer and the stability of rural industry, they have led to the modern tendency for control. A problem urgently requiring attention is to ascertain the true

desirability of such control, and if desirable, whether it should be achieved through education or enforced by economic measures or, under some circumstances, by direct legal control.

Careful social, political and economic studies are needed to evolve a land policy which will eliminate present abuses and at the same time preserve as far as possible the rights, initiative and incentive of the individual. The formulation of a policy which will encourage land prices to conform with the true earning power of the lands is a necessary adjunct to our rural progress.

(*b*) *Land Settlement and New Industries.* Land settlement schemes and the development of new industries will probably become important post-war issues when questions of immigration and the repatriation of soldiers and munition workers arise.

Future land settlement and readjustment provide an opportunity for land-use planning to ensure sound methods of development. The errors of the past in land settlement need to be squarely acknowledged if they are to be avoided in the future. Failures have been chiefly due to the growth of indebtedness, and the causes of such indebtedness should be mitigated or eliminated as far as possible. While national economic factors have contributed, local factors over which there is more control have also had a potent influence. Apart altogether from a careful study of general economic factors, local factors should, therefore, be given close attention in order to safeguard the stability of the settler.

Specific investigational work on the technique and economics of development and production should precede and form part of all settlement schemes. The choice of the land, its proper valuation on the basis of mean productivity, the choice of enterprises, the allotment of holdings of sufficient size in relation to long term prospects and the system of tenure best suited to the control of the land and its use, are pertinent problems. The selection, and if need be the training of settlers, to be reasonably sure of their chances of success, should be followed by competent supervision and advice.

The sociological approach is also important, as these schemes should aim to provide a worthwhile occupation for people who look to agriculture as a way of life. Group settlements to take advantage of cooperative action both from the economic and sociological points of view may be worthy of fresh consideration.

The war has provided a strong stimulus to the growth of new rural industries. Full development of Australian rural potentialities will involve the production of many commodities which have so far not been produced. Preliminary study in the field of markets is needed to determine what new industries may be worth trying. Likely fields of development include new crops and the development of new or partially exploited industries, including the processing of dairy products, fruit and vegetables, and the manufacture of oils, fibres and plastics from agricultural materials and by-products. The sound exploitation of such new rural industries involves an assessment of the possibilities of establishing the industry, economically based on experimentation and survey and costing trials in actual production. The emphasis needs to be on planned developments after adequate investigational work.

This summary should be sufficient to indicate the tremendous scope of the subject. It serves to show how emphasis on particular sections may present different sets of problems and different lines of thought. In this respect the reader is at least asked to keep perspective and remember that this is meant to be no more than a skeleton, and that detailed elaboration is a job for such as he.

If it be conceded that there is need and opportunity for research and advisory services in rural economics, the first obvious disability is the lack of trained peronnel. It may well be that this factor alone is the cause for hesitancy. If trained men were available, methods of procedure might soon be devised. The question is whether an organisation for the study of rural economics should evolve or be created. If created, then out of what ? If evolved, along what lines ? The matter ought not be left to the pure economist, and in this respect it would appear that it is easier for an agriculturist to develop proper economic thought than it is for the economist to develop the right agricultural thought. In the future it is hoped that economic ideas will enter more and more into both agricultural curricula and agricultural investigations.

An orderly development in Australia of rural economic endeavour is the main problem at present. It should be the aim of all to foster this development by encouraging the study of rural economic projects, by insisting on the incorporation of a truly economic bias in the teaching of agriculture and animal husbandry, and by advising existing administrators of the paramount need for co-ordination of effort in the various States of the Commonwealth.

(Received for publication, 5th February, 1942.)

Rural Surveys in Victoria

By

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An outline of two rural surveys being undertaken at the School of Agriculture, Melbourne University, may be of interest in view of the greater attention being given at present to agricultural economics. The object of the work is to obtain information on conditions of life in the country. It is sociological rather than economic; yet if we are to get a true understanding of purely economic findings such information is indispensable. Further, the method of carrying out a rural survey must present similar problems in both these branches of study.

The term "conditions of life" is used here in the widest sense. We are not so much interested in the income which the farmer earns from his wheat or butter-fat as we are in knowing what that income means to him. Does he work every day of the week? Does he use his spare cash and spare time in making his home comfortable and attractive? Or does he spend money on high-powered cars or machinery and put up with the discomforts of a pioneer's home? Besides his personal income, what is his share in the social services of the community? What are the facts of the drift to the city, how are the remaining farmers affected by it, and what do they think about it?

There seems to have been no major work done yet on these lines in Australia. The nearest analogy in this part of the world was the New Zealand survey* into the standards of life of dairy farmers, to which the present survey is indebted for many ideas. The present scheme consists of two parts, one research worker being engaged on each. These are firstly a survey of farms, and secondly a survey of rural towns and townships.

Farm Survey.

In the farm survey, wheat-growing and dairying are studied as individual industries. For each of these industries the investigator, using a method described below, chooses between 100 and 200 farms, and visits each by appointment. The approach to the farmer has been made easier by publicity in the farmer's hour on the radio, and by an explanatory letter sent soon before the visit, assuring the farmer of the confidential nature of the work, and acquainting him with its objects. The investigator has a long questionnaire which covers a large range of topics, and he records the farmer's information and opinions on as many of these as possible.

The first section of the questionnaire deals with the farm itself. This includes those figures for acreage and production of crops, reserves of fodder, and numbers of stock, which are commonly collected by the local policeman and added together to give the official estimates of the State's production. If financial information can also be collected, so much the better; but it is not essential. Productivity, however, is only one of many sides in this survey, and this knowledge is of value mainly for classifying the answers to the other questions. For example, we want to know how the amenities of the home of a high-producing farm compare with those of a low-producing, or those of a large farm with those of a small.

The other sections of the questionnaire deal with the human side. We want to know about the number of people on the farm, to have details about the house and garden, about accessibility to school and town, about their recreations and working hours and holidays, of their reading and their hobbies and what they listen to on the

* Doig, W. T., N.Z. Dept. Sci. Ind. Res. Bull. No. 75, 1940.

wireless. And by the time the investigator has dealt with all these questions, he will have formed a good opinion of the farmer's outlook on the world.

The survey of the farms has so far been confined to wheat farms, which at the time of writing are half completed. When this is done, dairy farms will next be tackled.

Sampling.—Within any one industry, proper sampling is vital. The wheat belt in Victoria is first delineated, excluding areas where wheat is not a major industry. It is then subdivided into twelve zones which differ in climate, soils, average size of farms and kind of agriculture, each zone being fairly homogeneous within itself. This step is essential, for one could not compare large farms with small over the whole of the wheat belt, since that would simply amount to comparing the drier zones with the wetter. Approximately one farmer in every 50 is next chosen from each zone, giving a total of 120 out of the 6,000 wheatgrowers in the wheat belt proper. For this purpose each zone is represented by one to four parishes, the number depending on the size of zone (the parish is the smallest statistical unit in Victoria, comprising about 50 square miles). These parishes are chosen so as to give a good geographical scatter over the zone ; an agronomist is asked to confirm each choice as really typical of the zone—parishes with abnormal yields are cut out. The properties within each parish are next grouped in terms of size (less than 500 acres, 500 to 1,000, and over 1,000 acres), and approximately one farmer in five is chosen at random so as to give the same proportional representation to each size-group as is shown by the statist's figures. In this last stage of choosing individuals, the data of the Wheat Stabilisation Committee are useful in giving the true areas of the holdings.

Detailed surveys of this sort always reveal some faults in the officially collected statistics. One of these is that farmers are often recorded as belonging to a parish adjacent to the correct one. The worst example of unreliability in the official figures was a parish which was recorded as having 25 farmers of whom 11 farmed 500-1,000 and 9 over 1,000 acres each, but which was found to have 35 farmers of whom 19 farmed 500-1,000 acres and 13 over 1,000 acres each. Most parish figures are much nearer the truth than this.

Dairying in Victoria is even more diverse than wheat-growing. There are the milk-producing districts near the metropolis ; the hills of South Gippsland, with their individual history of struggle against the wet forest ; the remote mountain valleys of the north-east ; the irrigated land of the Goulburn Valley ; the Western District from Colac to Port Fairy ; and other distinct districts. Climate, pastures, practices, size of holding, history of the settlement and alternative use of the land—all these differ so greatly that in the first place it is essential to study each district separately, though it may be convenient later on to group some of them together.

Township Survey.

The second part of the survey deals with country towns and townships. For this work the interviewer gets most of the information from men of wide acquaintance with the district—for example, storekeepers, schoolmasters and clergymen. The two main lines of inquiry are the amenities of the town and its place in the general economy both of the surrounding districts and of the nation.

The questionnaire goes into great detail. What sort of services are there of water, gas, and electricity, and of transport by road and by rail ? What is the standard of housing—are there any parts that could be called slums ? How is the township served by shops, and what local industries are there ? To what extent is the township a real social centre for the district, as regards sports and clubs and entertainments ? Is there any library or any serious development of intellectual

life ? Is there any interest in or demand for university extension work ? Is the population rising or falling ?

The first step in this survey was to classify all settlements of more than 250 inhabitants in terms of size. The census figures for 1933 showed that Victoria contained 354 " localities " of between 250 and 2,500 people, and 33 of over 2,500. The plan was to visit each of these places. It appears, however, that the majority of the 224 " localities " of between 250 and 500 people given by the census do not exist as townships. This is mainly due to the fact that the census figures for a locality often include all the farmers who make it their postal address. It is also probable that many townships have virtually disappeared on account of better road transport ; it may turn out that there is no place today for a township within 25 miles of a well-established settlement.

The investigators find that it requires about two days to collect the information for a town of about 1,000 inhabitants. As a rule people are fully prepared to give both facts and opinions, but at times there is need for a good deal of cross-checking.

(Received for publication, 10th February, 1942.)

Agricultural Economics in Western Australia

By

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In view of the economic problems in Australian agriculture, which have been discussed in this journal, and the need now felt for the establishment of studies in agricultural economics, it seems that this article might most usefully concern itself with an account of the work in this field which has been in progress in the Institute of Agriculture, in the University of Western Australia, for the past four years. First, however, it is necessary to correct an inference which might be drawn from most of the recent writings, namely, that Australian interest in the subject is of quite recent origin. This is far from being the case.

As far back as 1918 Perkins[6] drew attention to the need for studies in agricultural economics and in 1928, in his presidential address to Section K of the Australian Association for the Advancement of Science,[7] he made a strong plea for the establishment of organised agricultural economics research. In the same year, in a contribution to the *Economic Record*, Richardson[8] contrasted the progress made in agricultural economics in several other countries, whose systems of commercial agriculture were similar to our own, with the lack of interest shown in Australia.

Paterson drew attention to the need for a study of the business side of farming in his presidential address to Section K of the Australian and New Zealand Association for the Advancement of Science[5] in 1932. In most of his writings on agriculture in the past decade Wadham has emphasised the importance of the economic and sociological aspects of agriculture.

The Royal Commission on the Wheat, Flour and Bread Industries in 1934-35 found itself hampered in its investigation by inability to obtain accurate facts about the structure of these industries and in its report recommended that continuous studies should be initiated.

Most interesting of all, however, is the fact that in 1928 the Commonwealth Government was considering the establishment of an Economics Division of the Council for Scientific and Industrial Research.[3] At a meeting of this body in

December, 1928, the Minister, Senator the Rt. Hon. Sir George Pearce, referred at some length to the Government's ideas in proposing that work on economic research should be carried out. It was essential, he said, in connection with legislation and administration, particularly where such functions affect production, that those who direct these activities should have available economic facts scientifically ascertained and determined by examination and analysis of properly collected data. The Parliament, Government, or authority responsible for taking action might then do so, fully informed as to the economic effect of its action. It was also of great importance that public opinion, which ultimately decided policies, should be armed with correct information and scientifically ascertained facts as a basis for wise determinations.[1] The case for the establishment of a Commonwealth agricultural economics research organisation could hardly be more concisely stated than in these utterances by a Commonwealth Minister in 1928.

In January, 1929, the report of the British Economic Mission to Australia appeared. One of its recommendations was for the establishment of an Economic Research Bureau whose activities would be co-ordinated with those of the Council for Scientific and Industrial Research and the Development and Migration Commission.[2] The emphasis which the Commission placed upon the importance of the work of the suggested bureau apparently impressed the Government, for it decided to set up an independent organisation, instead of extending the scope of an existing one, and it passed an Act for that purpose. Unfortunately, the Act was never implemented. In the stress of the depression years the indiscriminate application of the axe in all avenues of government expenditure no doubt caused the project to be conveniently shelved and, so far as the writer is aware, nothing was ever heard of it again.

Although there is little to be gained by speculation on might-have-beens, it seems reasonable to think that, had the bureau come into being and developed as expected, there would now have been in existence a sound factual basis for a war-time agricultural policy, and possibly also an organisation better equipped technically for the formulation and administration of this policy than any of the several Commonwealth departments which are at present concerned.

Developments in the Western Australian Institute.

Through the initiative of Dr. J. E. Nichols, who was then Professor of Agriculture in the University of Western Australia, research work in the field of agricultural economics commenced in his department, which subsequently became the Institute of Agriculture, in 1938. The work was financed with money from the Commonwealth grant to universities, supplemented by funds from the Trustees of the Wheat Pool of Western Australia. The cooperation of the State Department of Agriculture resulted in the services of one of its advisory officers being made available for this work. After completing a degree in Agriculture this officer had received additional training in Economics. A graduate in Arts and Agriculture and another graduate in Economics have also carried out post-graduate research work at the Institute for varying periods during the past three years. The uncertain continuity and limited amount of the funds available have somewhat restricted the scope of the studies that have been made. However, quite apart from the usefulness of the information that has been collected and analysed, valuable experience has been gained by the investigators. They have been brought into close contact with research workers in other lines of agriculture within the Institute to their mutual advantage; they have obtained a first-hand knowledge of a number of agricultural problems, and they have learned something of the difficulties associated with investigational work in these fields. One fact that has been made evident during the course of these studies is the necessity for a thorough knowledge of local agricultural practice on the part of the investigators.

The first study made was of the costs of tractor farming in the Western Australian wheat belt. Although the sample could not be considered as adequately representative of Western Australian tractor farmers, the study did emphasise the principles underlying the economical use of tractors in the wheat belt. It showed that an expensive tractor had to be worked as near to capacity as possible if it was to be economical, and it demonstrated how surprisingly efficient and economical a modern tractor could be when properly used. It was also possible to make a comparison between tractors worked on kerosene, fuel oil and producer gas. A supplementary survey was made of the use of producer gas on farm tractors, at a time when this type of machine was increasing in numbers in Western Australia, but receiving very little attention in other wheat growing States.

The investigation into farming costs in a wheat belt district was designed partly as an exploratory survey to determine the suitability of this method of investigation to Western Australian conditions. The sample consisted of all the farmers who carted their wheat to a certain railway siding. A detailed study was then made of the operating costs of this sample of farms. In a limited number of cases it was also possible to obtain data regarding farm income. A report has been prepared on the result of the first year's work on this project.

A study of another type, which was recently completed, concerned the pig industry of Western Australia. It is thought that there is considerable scope for this kind of study in Australia at present, and that agricultural economists are fitted, by their training, for it. They should be better able to look at an industry as a whole and to gauge the relative importance of problems concerning it than the majority of specialist workers It is by no means improbable that, at some stage in the development of an industry, the factor limiting progress may be economic in character, in which case its critical importance might pass unrecognised by the technical worker.

Statistical Defects.

Even though such studies may do little more than draw attention to statistical deficiencies and suggest lines for further investigation, they should be worth while, for they do establish a basis for future action.

Each of these investigations has involved a thorough examination of existing statistics, and has afforded the workers an opportunity of obtaining access to the records of a number of farmers.

In all cases the first impression received was that the existing official statistics were completely inadequate for the purposes of the agricultural economist. In the tractor survey, for example, it was found that there were no tractor statistics of any sort collected for Western Australia before 1928, and since then the only yearly collection made was for total numbers and the owners' valuations. Nothing whatever was available concerning type, nature of fuel, age or purposes for which used. Information concerning the pig industry was only slightly more comprehensive. The most striking deficiencies occur, however, in statistics relating to the farm business, for no figures are collected for vitally important items such as farm income, indebtedness and land values.

It is likely that the agricultural statistics of other Australian States suffer from similar deficiencies. Perhaps it is not very surprising that there should be these gaps in our knowledge concerning the operation of one of our major industries, for, until recently, nobody has been particularly interested in examining and analysing this sort of data and there has been no incentive to collect it. Even in the U.S.A., where the agricultural statistics are probably the best in the world, agricultural economists complain that they do not always furnish the data which are the most useful for their purposes. However, in Australia, it will be one of the more immediate major tasks of any agricultural economics research organisation to obtain the co-operation of government statistical departments in reorganising and extending the

scope of agricultural statistical collections. The experience in Western Australia has been that the Government Statistician and his officers welcome suggestions for improvements in the statistical collections and are willing to cooperate to the fullest possible extent, but that they are not in a position to make major changes when both staff and modern statistical machines are lacking at head office, and the collection of the information in the field has to be relegated to officers of another department, namely police constables.

Sampling Technique.

Although inadequacy of published statistical data is a serious handicap, the most difficult problems are encountered when endeavouring to obtain data from the farmers. Modern statistical technique has made it possible for small samples of a population to be selected of such a nature that, if adequate precautions have been taken, they can reasonably be regarded as representing the whole population. The Gallup polls have been made possible by use of this technique and its application to agricultural statistics is at present receiving considerable attention in the U.S.A.[4] However there is little to be gained by careful selection of a sample if the individuals which constitute it are unable or unwilling to supply the information which is sought.

Experience in Western Australia has shown that only a very small proportion of wheat farmers are able to supply information about their business in sufficient detail for the purposes of an investigation. When making the tractor survey, for example, questionnaires were sent to about 300 operators, whose names had been obtained from various sources as men likely to have reliable records. Only six were able to give figures of any value but 170 said they would keep the required records during the next twelve months. Each of these operators was supplied with a record book and instructions on how to keep it. At the end of the period only 46 were able to return books which gave all the information required for the full twelve months' period. Thus, even in a case where a certain amount of preselection had taken place on the basis of willingness to assist, the greater number failed in their undertaking. Had the sample been a random one, then the percentage of failures would have been even larger.

It seems certain that some kind of sampling technique will have to be extensively employed for this type of agricultural economics work in Australia and equally certain that, if it is to be successful, some sort of financial inducement will have to be offered to the farmers who constitute the sample to keep their records in the way desired by the investigator. It is useless to suggest to the farmer that it is in his own interests to keep a comprehensive set of books. A number of those who would be included in a random sample would have nothing to gain from the effort they would have to make in keeping an accurate record of their transactions.

The mere collection of data is neither the only nor even the chief task of the agricultural economist. But a large amount of factual material is an essential preliminary to correct analyses and sound generalisations, and while the work may appear pedestrian, the making good of deficiencies in data is likely to occupy the attention of workers in agricultural economics in Australia for some time to come.

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Victorian Horticulture—Today and Tomorrow?

By

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Some analysis of Victorian horticultural industries should be made before the war is concluded so that, in post-war readjustments and in the probable absorption of some of that large body of Australians now fighting or engaged in purely wartime activities, planning will be wisely considered and major errors avoided. Intensive agriculture of this type has been in the past and probably will continue to be an attractive means of land settlement because the relatively small areas facilitate supervision and because community life in such forms of agriculture is more similar to that in cities from which most new settlers are drawn. Even now army authorities are trying to develop horticultural training in military camps.

Although in total value of their production, horticultural industries are overshadowed by some other primary industries, they are of relatively much greater value because of the rural population they support. There are, in Victoria, about 108,000 people permanently engaged in rural pursuits on about 7,500,000 acres of cultivated land. The area under vineyards, orchards and market gardens is approximately one-sixtieth of this total cultivated area, but about one-sixth of the rural population is dependent on these industries. The following figures show the area and gross return to the growers of the main three divisions of Victorian horticulture in 1939-40. The grape industry is by far the largest horticultural industry, and, in Victoria, is third in agricultural importance to wheat and hay.

Vineyards (mainly dried fruit)	42,594 acres	£2,370,814
Orchards	70,315 ,,	1,653,849
Market gardens, etc.	25,863 ,,	1,365,964
	138,772 ,,	£5,390,627

The crop obtained in 1939 from the 70,000 acres under orchards gives an indication of the relative importance of the several fruits though apples were light in that year.

Apples	1,603,403 bushels
Pears	1,298,787 ,,
Peaches	1,201,378 ,,
Apricots	485,612 ,,
Plums and prunes	201,615 ,,
Citrus	665,342 ,,
Other large fruits	111,683 ,,
Berry fruits	12,594 cwt.
Nuts	151,949 lb.

The areas under "other large fruits", berry fruits and nuts, are seen to be relatively unimportant. This is not because of the unsuitability of Victorian conditions for their growth, but is due to the normal tendency in Australian agriculture to concentrate on main commercialized crops rather than on a diversification of production. Nevertheless, the latter course offers us appreciable opportunity for post-war expansion or reorganisation. In nearly all of the main fruits special economic problems occur, which should be thoroughly discussed and a policy decided upon prior to any extension or reorganisation. The post-war export position of our fruit industries will exercise a major influence upon what shall be done; but it seems most unwise entirely to delay consideration of the whole problem until the

war is over. A detailed economic survey is necessary now to fit us to approach post-war problems efficiently. It would be incorrect to assume that responsible authorities at present have adequate data. It would be equally incorrect to believe that, with present depleted staffs, an adequate survey could be undertaken, unless special provision were made for it by the Government.

Dried Fruit Industries.

The rise of the dried grape industry since the last war has been one of the most satisfactory features in Australian agriculture. Being prosperous, it has a natural tendency to attract newcomers to the industry, but competent authorities have urged for a considerable time that further expansion of dried grape production in Australia is undesirable. We have, therefore, a case of an industry which has been thoroughly planned for a number of years and has been brought to a stage of prosperity and efficiency, and yet is asking for further control to avoid ill-considered expansion. It is a contrast to the conditions usually attached to control in Australian agriculture, in which restriction is suggested after the industry has become unprofitable. Probably for this reason, warnings against increased planting of grapes for drying are not always accepted readily.

Australian production of dried grapes, of which Victoria is responsible for about two-thirds, has risen from about 35,000 tons in 1925 to between 90,000 and 100,000 tons at the present time. During this period, very important markets have been obtained in Great Britain, Canada and New Zealand, which absorb 49,215 tons, 19,835 tons, and 5,129 tons respectively, all other countries absorbing only 854 tons.

The British market is estimated to be able to absorb under reasonably favourable conditions, about 125,000 tons per annum drawn from Australia, United States of America, Greece and Turkey. Taking into consideration the political relations between Great Britain and these countries, and the fact that our crops are delivered fresh during the months of April to September when they then meet the new crops from the Northern Hemisphere, it is unlikely that more than 50,000 tons of Australian fruit could be placed profitably on the London market, that is to say, we have just about reached the limit of this market under prevailing conditions. In Canada, we have practically wrested the whole of the market from California, while New Zealand also relies principally on Australian fruit. It must not be overlooked that Australian sultanas enjoy a preference per ton of £10/10/- in England, £18/13/4 in Canada, and £13/13/4 in New Zealand. Without this preference, the financial position of the Australian industry would be very different from what it is today. We have not been able to develop any substantial markets in countries other than those granting financial preference to our fruit.*

Some years ago an agreement was reached by the governments of the several producing States in Australia that they would not sponsor State schemes for the expansion of the dried grape industry. It seems reasonable to suggest that restriction of planting even in or near existing settlements is desirable in the interests of the dried fruit industry and that further planting should not be permitted without approval from some properly constituted authority. Sometime ago, the Standing Committee on Agriculture created the machinery for the appointment of a committee to investigate the proper utilisation of land of the Murray Basin. This committee, however, did not think itself the proper body to undertake the detailed investigations of the economic position of the relevant industries. The dried grape industry has been for a considerable time most anxious that some authority should thoroughly examine the evidence available.

The dried tree fruit industry is also quite profitable at the present time, although a few years ago this certainly was not the case. Improved processing methods for

* Since this address was delivered trade agreements made between Great Britain and the United States seem likely to eliminate such preferences.

prunes particularly have resulted in an increased Australian demand, and judicious publicity has assisted. Dried apricots, peaches and pears, which together do not equal half the prune pack, are at present not available for civilian purposes, our production being insufficient for defence needs. There is unquestionably room for some expansion of this industry, which produces annually about a million pounds weight of dried fruit. Only prune varieties listed under the Dried Fruits Act are controlled by the Dried Fruits Board, with the undesirable effect that growers are drying other plums not so suitable for drying, simply to avoid complying with the requirements of the Dried Fruits Act as to premises and the observance of proper quotas. It is hoped that the several Dried Fruits Boards will agree to include all dried plums in the regulations, for it is most undesirable, from a Victorian horticultural view, that the less suitable varieties should be planted if expansion is contemplated.

Apples and Alternatives.

The general position of the industry in Victoria is rather more stable than in certain other States, because of the proximity of Victorian areas to the Melbourne market ; but there are some Victorian apple districts which have been and will be after the war, mainly interested in export. The financial returns from apple exports over a number of years prior to the war were hardly payable and voluntary restriction of Australian exports to Great Britain, our only substantial market, was practised in an effort to hold prices there at a reasonable level. It does not appear that the British market could absorb more fruit than in the years referred to, and any expansion of apple areas would, of course, be unwarranted.

The export apple districts have been, however, reasonably profitable in 1941 under the acquisition scheme and confidence may arise which may encourage the planting of limited areas for young men returning from the A.I.F. who, prior to the war, were still content to assist on their parents' properties. Apples, sheltered by government action during the war must, however, on its conclusion, face the cruel blasts of peace. It would, therefore, be desirable for any expansion of fruit growing in these areas to take place in some of the minor crops, at present under-produced.

In our northern districts almonds and probably cherries, which at Harcourt do very well, would extend the harvesting and marketing period very considerably. In the south of the State, cherries, and in some situations berry fruits, could be planted. There are, for instance, still large undeveloped areas of red soil in the Dandenongs capable of growing cherries, berry fruits and other small crops satisfactorily, but extension into small fruits might require increased assistance from the Department of Agriculture in cultural directions and some form of assistance which would enable an organisation of berry growing that would permit it to compete with other well-organised fruit industries. This list of alternative crops could include, besides figs and other fruits, the new industries of seed and herb production being now stimulated by the war. The production of vegetables by apple growers, looked upon as a temporary expedient at the present time, might be consolidated in favoured situations. Whether some reduction of apple areas is possible to enable changes of this sort to be made is a matter which might be investigated by some competent authority.

Pears.

The position of pears is much better than that of apples. Export prior to the war was satisfactory, and is likely to continue to be so after the war, even with some expansion in the planting of export varieties. The home market seems to be able to maintain pears on a sound basis without export. Gas storage of such long-keeping pears as the Winter Cole would now enable fruit to be sold in good condition as late as December, and justify the expansion of this and similar varieties not very extensively planted at present.

Citrus.

The citrus industry made very rapid growth in Victoria following the last war, the total acreage increasing from 1,837 in 1917 very steeply to 5,221 acres in 1929, and more gradually since then to something over 6,000 acres of bearing trees at the present time, of which about 80 per cent. would be Washington Navel and Valencia oranges. The rate of increase prior to 1929 was so great, that the Commonwealth Government had an investigation made and a report published in 1929 by the Development Branch of the Prime Minister's Department, which expressed the opinion that by 1936 production of oranges would have reached such a level in Australia that an exportable surplus of 1,000,000 cases would be produced. This forecast, however, was not realised owing to a decline of mandarins, oranges and commons in the New South Wales areas which were expected to produce by 1936, 3,138,000 bushels of oranges, but which actually produce, even at the present time, a good deal less, on the average, than 2,500,000 cases. Victoria and South Australia, on the other hand, which were forecast to produce in 1936, 1,079,520 cases, actually passed this total in 1932 and at the present time produce between them about 1,500,000 cases of oranges annually. Since 1928-29, New South Wales production has dropped from about 65 per cent. of the Australian orange crop to 55 per cent. at the present time, while Victoria and South Australian production has during the same period risen from 21 to 31 per cent.

From the Victorian point of view, the increase is even more significant because in 1929 about 50 per cent. of production was in the Goulburn Valley, which has since steadily declined and now produces not more than 20 per cent. of the Victorian crop of oranges. Increases have occurred in the Murray Valley, which have been due to the greater financial return from groves in this region. The quality of the fruit produced in the Lower Murray Valley apparently has exceeded that of other Australian districts to such an extent that while this zone has gone ahead, the Goulburn Valley and important established regions in New South Wales, quite close to Australia's biggest market of Sydney, have seriously declined.

It seems natural to expect a further increase of orange production in the Murray Valley of Victoria. There has been in recent years some concerted planning at Murrabit, a relatively late district and not typical of the usual Murray Valley soils, but in the lighter soils to which attention is particularly directed, no concerted action has been taken, the increase coming from a number of individual plantings in widely scattered parts. The citrus industry itself is enquiring into the general position and with the assistance of the Department of Agriculture is conducting an acreage survey at the present time, but it would seem that this matter might reasonably be considered by an authority empowered to enquire into the use of the entire Murray Basin for dried fruits, citrus and other horticultural purposes. To open up new areas, suitable land is available, but whether there is sufficient water is not known.

It is to be hoped, however, that in any extension of the citrus industry, the lessons of the last twenty years will be thoroughly kept in mind. They indicate principally, that citrus production cannot be planned for large solid settlements, only pockets of land, principally sand ridges in the Murray Valley, being suitable for citrus production. This is an added reason why extension of the citrus area might reasonably be considered in relation to the extension of other crops in that region. In the Mildura district, for instance, although there are 826 growers of citrus, there are less than 50 with more than 400 trees who might be classed as citrus growers primarily; the remaining citrus trees in this important producing region are in small blocks which have persisted from earlier and larger plantings, or which have been specially placed on small areas of suitable land.

Canned Fruits.

The canned fruits industry, like the dried fruits and citrus industries, is well organised, and, at present, reasonably prosperous. It has made striking advances during the last fifteen years.

Victoria is the principal producer of canned fruits among the Australian States, though of recent years the Murrumbidgee area in New South Wales has played a prominent part. The total Australian production has approximately doubled in the period 1926-40 and is steadily increasing. Apricots, which declined because of unsuitable varieties, principally Moorpark, in the period 1931-35, have again returned to public favour, and with improved varieties which ripen more satisfactorily, such as Trevatt and Tilton and Shipley, this section of the industry is progressing. The rise of peaches during the last five years is more striking because in the Goulburn Valley wet winters have reduced production, and Oriental Peach Moth has, in certain years, decimated the late crops. Pears have steadily increased in the Goulburn Valley, and it would seem that this is the canned fruit most suited to the area, and the one in which the district is likely to lead Australia. As peaches decline because the soil conditions are really not quite suited to them in many parts of the Goulburn Valley, pears replace them, and both in yield and quality are more satisfactory. It would be possible, if necessary, to greatly extend the canning campaign by gas storage of the pear crop.

The advance in canned fruit production has, of course, been stimulated by the thoroughly satisfactory export position up to the outbreak of hostilities. Export has been increased threefold since 1930 due to better quality and to greater efficiency in the industry following organisation and the elimination of wasteful competition between selling agencies. Sales by the Canned Fruit Control Board, at more competitive prices than previously, have assisted in increasing the demand. Despite these lower prices on the export and also on the domestic market, growers, over several years, have received for fruit delivered to the canneries thoroughly payable returns. As the Canned Fruit Control Board in the 1939-40 report says, it is a pity that as our fruits were manifestly growing in popularity in Great Britain, normal trade has been interrupted by the war, and post-war problems will need very careful scrutiny. The domestic consumption of canned fruits in Australia too has been doubled since 1933, a very striking performance indeed. Like the export market, the home market has responded to better quality, due not only to improved technique but also to the planting of a greater percentage of improved varieties. Reduced prices have, of course, been equally important.

The future of this industry seems bright. Though it would be foolhardy to suggest the planning of vastly increased production, the planting of canning fruits, largely peaches, in the newly opened Cobram irrigation area, indicates the confidence with which the future is viewed, and we can reasonably look to a continued increase of pears in the remainder of the Goulburn Valley.

Market Gardening.

Victoria has for long been known as the " cabbage patch of Australia ", because of the extensive market gardening and other intensive forms of agriculture practised in this State. While the rapid and considerable extension of vegetable growing in New South Wales, Victoria's best external market, has reduced the dependence of that State on Victorian supplies, the industry in Victoria remains in a very sound position, and supplies as a whole do not equal the demand. There is ample room for further extension of the industry for two main reasons.

In the first place, the country districts of Victoria are not nearly as well provided with vegetables as is the city of Melbourne. Prices are usually much higher and the quality lower, owing to long transport under unsuitable conditions and the necessity for holding in poorly equipped country shops. While better organisation of vegetable

sales to country districts would help the position, a better plan would be the opening up of vegetable growing areas as near to the centres of consumption as possible, and many of our northern districts, where irrigation is available, show possibilities in this direction. The rapid growth of tomato production in the Goulburn Valley during the last few years is one illustration and the possibilities of early vegetables at Mildura, for instance, are obvious. It is not suggested that all the produce of such areas should be consumed locally. They would, in addition, spread the season of Victorian supplies to the Melbourne market, and tend to even up the prices and supplies of vegetables throughout the year.

The second reason why definite extension of market gardening seems possible in Victoria is the rapid growth of vegetable canning in the last couple of years. This has been brought about mainly by the necessity for supplying canned vegetables to overseas forces, but it will inevitably increase the interest of Victorian people in canned vegetables, and, further, may permit the export of vegetables after the war. Trade in vegetables to the East, for instance, has always been hampered by our inability to carry many vegetables in a satisfactory condition. Many canned vegetables are superior in quality to fresh vegetables, as they can be picked and processed at the optimum stage and can be used at a time of the year when fresh vegetables are too high in price for many households. As in the case of canned fruits, so increased production of canned vegetables will reduce the selling price, improve the quality and very greatly increase sales. There is no primary industry which absorbs labour to a greater degree than market gardening, and the costs of establishing a living area are comparatively small.

Conclusions.

The foregoing comments on the several branches of Victorian horticulture have reference to the possibility that after the war many people will look to them for their livelihood with the financial assistance of the State. The guiding of such people into channels which will give them and the community most satisfaction in later years demands a detailed survey of the present position and future prospects of the several branches of horticulture. The survey should be made now, if the last-minute rush of the previous war period is not to be repeated with similar unfortunate results.

Even without considering the problems of demobilisation, the welfare of those already in the industry warrants similar action. Further, the present tendency to segregate growers into water-tight compartments according to the type of fruit they grow seems undesirable. Sooner or later surely we shall regard the good growers as trained men and an asset to be used to the best advantage. If a skilled grower is forced to leave his holding, normally he has to seek employment in the cities, owing to his inability to finance a new venture ; while an unskilled man with the necessary finance can accept an opportunity of horticultural production elsewhere. Again, even in these critical times of labour shortage we have schemes for keeping growers in over-produced industries, but no comparable schemes for transferring them to alternative production, which would be of greater profit to themselves and the state.

The several boards associated with many sections of Victorian horticulture are not empowered to correct such troubles, and as a matter of fact are likely, at times, to accentuate them. Unless some means is found to co-ordinate the work of the several boards, we may build a structure of perfect bricks but without mortar. The mortar could be provided by a detailed survey of these industries conducted by some suitable authority, and the bricks could then be built into the chosen design by our legislators.

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Progress in Soil Physics

By

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Soil Physics, by L. D. Baver. (*Pp. xi*+370 *with* 4 *plates*, 70 *figures and* 54 *tables. John Wiley and Sons, New York*, 1940. *Price* 4 *dollars.*)

Soils and Soil Management, by A. F. Gustafson. (*Pp. viii*+424 *with* 165 *figures and* 66 *tables. McGraw-Hill Book Co., New York*, 1941. *Price* 3 *dollars.*)

Manual of Sedimentary Petrography, by W. C. Krumbein and F. J. Pettijohn. (*Pp. xiv* +549 *with* 265 *figures and* 53 *tables. D. Appleton-Century Co., New York*, 1938. *Price* 5 *dollars.*)

The Physics of Blown Sand and Desert Dunes, by R. A. Bagnold. (*Pp. xx*+266 *with* 16 *plates and* 84 *figures. Methuen and Co., London*, 1941. *English price* 24/–.)

A great deal has been accomplished in soil physics since the publication of Keen's *Physical Properties of the Soil* in 1931. For this reason the appearance of several books dealing with advances in this and related fields is very welcome. Of particular interest is L. D. Baver's *Soil Physics* in which a review is given of the most important developments. A good introduction is provided to the principles of water movement in soils, the physical composition of soils and soil colloids and the theory of mechanical analysis. The material is logically and clearly presented, along the lines of the author's university lectures, with sufficient treatment of fundamentals to provide a coherence to the whole. This book should be of value to students and research workers alike.

So many aspects of soil physics have a bearing on some relation between soil and water that advances made in the study of the movement of water and its retention in soils have been important to the whole field. Progress has been made possible by the use of the capillary potential theory introduced many years ago by Buckingham. This deals with the energy changes involved when water is added to, or removed from a soil. Practical applications were limited until suitable methods of measuring the potential had been developed. Since these became available recently, marked advances have been made.

The development of this theory and its bearing on water movement, water retention, availability of water to plants and the specification of soil structure are discussed fully in Baver's book. One simple application will provide an example of its usefulness. The permanent wilting of plants occurs at a higher water content in a clay than in a sandy soil. However, it has been shown experimentally that wilting occurs at about the same capillary potential in all soils. In other words the energy level of the soil water gives a direct measure of the availability of the water to plants.

The capillary potential theory has also made possible the development of new methods for investigating soil structure. Baver has himself made contributions to the measurement of pore size and this, together with his familiarity with Russian work, has resulted in an excellent chapter on structure. He points out that in many soils the structural arrangement of the particles is as important as the composition given by complete dispersion in a mechanical analysis. The degree of aggregation and the stability of the aggregates affect the physical behaviour of a soil profoundly. Degeneration of structure, under cropping rotations which involve frequent cultivation, is a major cause of decline in soil fertility. Structure has been studied by dry-sieving, wet-sieving and sedimentation methods, for all of which arbitrary standardisation is necessary. These methods measure aggregate sizes but for many

purposes the specification of pore sizes would give a more satisfactory picture. This can be accomplished by employing the principle that the largest pores in a soil are emptied first when a progressively increasing tension is applied to soil water. Provided certain theoretical limitations are recognised, it is possible then to obtain a size distribution of the soil pores.

From a knowledge of pore size and total pore space, it should be possible to obtain a good index of the permeability of a soil to fluids. But, as can be seen from Baver's discussion of Slichter's and Zunker's work, attempts to express permeability as a function of the structure have always stressed either particle diameter or specific surface. A departure from this was introduced recently by Bodman, who employed an " effective radius " of pores obtained by relating Poiseuille's law for flow through capillary tubes and Darcy's law for flow through porous media. A still more direct approach has been made possible by considering the distribution of pore sizes in the medium. Baver provides some useful correlations of permeability with the occurrence of the larger pores, but a critical evaluation has yet to be made of the effectiveness of the different pore sizes in contributing to the permeability of the whole. This should provide a promising line of future investigation.

For the usual permeability determinations, flow is measured under saturated conditions.* Recently, however, techniques have been developed for measuring flow in soils and soil colloids maintained at any required degree of unsaturation. In such cases the water moving force is given by the sum of the gradients in capillary and gravitational potential. Baver deals at some length with the results of these experiments. They have shown quantitatively that water conductivity or permeability decreases rapidly as the " tension " and degree of unsaturation increase. This has an important bearing on the management of fallows following summer rains. By the time a soil has drained and evaporated sufficient water to be in a fit condition for cultivation, the rate of water movement by conduction will have greatly decreased. Mulching of the surface at that stage cannot be very effective in restricting water loss.

When there is a shallow water table, on the other hand, upward movement will often be sufficiently rapid to allow significant conduction of water to the surface. Under these circumstances—which are those of the classical experiments of King—the creation of a dust-mulch can be effective in restricting water loss. There are many other cases more particularly in subsoils when flow under unsaturated conditions is important. In this connection Baver quotes freely from Moore, who has demonstrated the very interesting fact that, when soils are unsaturated, movement is more rapid in a clayey soil than it is at a corresponding potential in a sand.

In dealing with soil erosion, Baver has made a commendable selection from the large volume of work now being undertaken in that field. In a descriptive equation, he defines erosion as a function of climate, topography, vegetation and soils. Climate and vegetation are of course of prime importance and are usefully discussed in this section. While angle of slope does not affect run-off greatly it has an important influence on the degree of erosion of a soil. Of the soil properties influencing run-off and erosion, the one most widely studied is that of infiltration or the rate of entry of water into the soil. This is measured by allowing water to enter the soil under a low head or under the application of artificial rain. The initial water content of the soil is of course an important factor influencing infiltration and, where water is being continuously applied, the rate of entry falls off with time. The results obtained by such measurements have a close bearing on the relation of climatic factors to run-off and erosion. Questions of structure also enter into the

* A detailed treatment of Darcy's law and of potential theory in relation to flow under saturated conditions is given by M. King Hubbert, *The theory of ground water motion*, 1941, *Univ. of Chicago Press*, 1·25 *dollars*. (*Reprinted from Jour. Geol.*, 48, 1940.)

picture, particularly when the soil is cultivated and the surface suffers from the direct impact of falling rain drops. Baver discusses fully the significance of stability of structure and degree of aggregation in relation to erosion. He points out that while good granulation may reduce erosion with light rains, compaction may in some cases be more effective under heavy rains. In general, however, any factors assisting permeability will help also to resist run-off and erosion. The effects of the various soil factors on erosion are usefully summarised at the end of this section in a further descriptive equation.

The applied field of soil mechanics which deals with soils in foundations and in dam construction has unfortunately been omitted by Baver, although the underlying knowledge concerning soil consistence is covered satisfactorily. One could also have wished for some treatment of the problem of soil colour to which the use of Maxwell discs has contributed at least a partial solution. Difficulties in the way of accurate colour specification of soils are admittedly great, not the least serious being the variation in colour –particularly in brightness and purity—corresponding to different water contents of a soil. However, the subject merits attention, since such wide use of colour is made by the soil morphologist, as for example in the names of some of the great soil groups—Black earth, Brown earth, Red-brown earth. Apart from these more notable omissions, and a small number of errors in the text, there is little to criticise in this book.

Soil Management.

Soil management is discussed in *Soils and Soil Management* by A. F. Gustafson. The book is intended for students and farmers and the treatment is elementary. In many respects it forms a useful supplement to Baver's *Soil Physics* since much of it is devoted to soil physical and agricultural engineering applications in irrigation, drainage, tillage, water conservation and erosion. Methods of irrigating—by sprinklers, furrows and by the various flooding systems—are described more fully than is usual in books by writers not immediately concerned with such problems. Types of implements and the reasons for cultivation are given in some detail in the chapter on tillage. Inter-row cultivation is discussed and results are quoted of experiments illustrating the fact that the main benefits from such practices are derived from the control of weeds.

In dealing with water relations, the author draws attention to the advantages in expressing water contents of soil samples on the oven-dry instead of the wet basis when percentages are given by weight. This is not always done in this country, where for example the water content, among other results of a mechanical analysis, is frequently given on the air-dry basis. This value is not then directly comparable with other field or laboratory water contents, all of which are normally calculated on the oven-dry basis. Moreover, when the results of a mechanical analysis are presented on the oven-dry instead of the air-dry basis, simplicity is gained by the elimination of " water content " from the list of fractions which needs to be presented.

In a book dealing with soil management, some mention also might have been made of the fact that, for field work, water percentages are often better expressed by volume than be weight. The amount of water present in the soil can then be readily converted to surface inches of rain or irrigation. This and other advantages to the volume basis have been set out by Baver.

Gustafson deals of course with other aspects of soil management than those immediately associated with soil physics. Sections on fertilisers, green manures and rotations are included in a well balanced table of contents. Although the treatment throughout tends to be somewhat superficial, the simplicity of the book and the use of over one hundred well selected photographs will make it of general interest.

Mechanical Analysis.

Details concerning mechanical analysis are admirably given in a *Manual of Sedimentary Petrography* by W. C. Krumbein and F. J. Pettijohn. The first half, written by Krumbein, gives probably the best available account of the principles of sieving and sedimentation and the graphical and statistical treatment of the results. A complete guide is provided for the worker in mechanical analysis from a table giving the capacity of sample bags to the design of a simple stirring rod widely used for agitating suspensions in United States soils laboratories. The author gives a healthy criticism of current dispersion procedures and points out that for the finer particles, dispersion of aggregates is indistinguishable from crystal disruption. However, although the size distribution may in fact be a function of the dispersion process, it is also true that modern procedures yield reproducible results. A clearer statement of this point should perhaps have been made. The sections dealing with the theory of sieving, mechanical methods of sieving, and the graphical representation of results are of particular value to the soils worker since they are not usually dealt with in detail in his own literature.

The second half of the book, which bears the sub-title "Shape analysis, mineralogical analysis, chemical analysis and mass properties", does not come within the scope of this review. However, one cannot pass the statement, which appears also in Gustafson's book, that the hygroscopic coefficient is the amount of water held by a soil in equilibrium with a saturated atmosphere. In the case of a soil placed in an atmosphere which is in equilibrium with a free water surface, water will be adsorbed very slowly until the soil is virtually saturated. The slow rate of uptake after 24 hours' exposure has often been misinterpreted as an indication of equilibrium. Measurements of hygroscopicity to have any real meaning can only be made at some stated relative humidity. This procedure has the additional advantage that it provides a means for assessing the capillary potential of soil water at water contents below permanent wilting.

Blown Sand and Desert Dunes.

Another publication of unusual interest is Bagnold's *Physics of Blown Sand and Desert Dunes*, which deals chiefly with the author's own pioneering work in that field. The book is divided into three sections: the physics of grain movement, small-scale effects, large-scale effects. The theoretical and experimental treatment of the first section is of particular interest. By means of wind tunnel and field observations, Bagnold has demonstrated that sand grains move mainly by surface creep or by a bouncing motion called saltation. When a wind has reached a threshold velocity which is critical with respect to particle size, sand is moved upward and forward by the wind. Each particle, after descending, may bounce or it may impart its kinetic energy to other particles which it dislodges with an explosive action. Particles too big to be lifted may be pushed along as surface creep.

It is of interest to note that Bagnold's methods have recently been used by Chepil in studying wind drifting of wheat soils in North America. Structural aggregates have a lower density than sand grains and rather different critical limits were found. Aggregates above 2 mm. in diameter protected the surface. For this size, a wind of 30 miles per hour measured at a height of 12 in. was necessary before movement occurred.

The second section of the book includes a discussion of ripple formation and of size distribution diagrams. In the latter connection, the author refers frequently to the book by Krumbein and Pettijohn and includes, as well, some original material not given there. In dealing with sieve calibration, Bagnold points out that kinks in grading curves can be made to reveal a sieve error provided they can be shown to correspond to the same size range in curves for unrelated sands.

The third section falls more within the province of the physiographer and is largely descriptive. A detailed account is given of the structure and origin of sand deposits and true dunes. The former are described either as sand drifts or sand shadows and are formed as a result of obstructions in the path of the sand. The latter are formed in an erosion desert and are either crescentic (barchans) or longitudinal in shape. In discussing the strength and direction of winds in relation to the formation of these two types of desert dunes, the author makes considerable use of Australian work by Madigan. The book concludes with an entertaining account of whistling beach sands and booming desert sands.

Future developments in soil physics are likely to be stimulated, as in the past, by problems in irrigation, drainage, evaporation from soils, water availability to plants, tillage, soil mechanics and soil erosion. In comparison with other sciences, soil science developed late during a practical age. As a consequence, soil physics, like other branches of the science, at first lacked an adequate background of fundamentals. Where such a background was present it was not linked up sufficiently with these practical problems. A comparison of Baver's *Soil Physics* with earlier books on the same subject by Warington, King and Keen, gives some justification for the belief that a great advance has been made in this direction and that a healthier balance now exists.

(Received for publication, 9th January, 1942.)

The Influence of Storage in Contact with Certain Seed-Pickling Dusts on the Germination of Grain

By

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I. INFLUENCE OF TEMPERATURE AND TIME OF STORAGE ON THE GERMINATION OF WHEAT.

When testing fungicidal dusts for the treatment of wheat it was observed that wheat treated with a dust containing ethyl mercury phosphate as an active principle may suffer a serious loss in germination when stored a few weeks prior to planting. For example, wheat of the variety Ranee stored four weeks after dusting gave a germination of only 41 per cent., in contrast with a germination of 87 per cent. by undusted grain similarly stored.

Mercurial dusts of this type are used in North America and it was thought that the depression in germination observed may have been due, among other things, to the higher temperatures in South Australia during the late summer, when much of the seed grain is dusted for planting.

Experimental Procedure.

In order to test this possibility, wheat of the variety Ranee, treated with a series of 10 dusts, was stored for periods of 0, 2, 4, 6 and 8 weeks at temperatures of 0°, 10°, 20° and 30° C. All dusts were applied at the rate of 2 ounces per bushel and the dusting dates were so arranged that all treatments were ready for sowing on the same day. The dusts included were:

(*a*) An experimental dust containing 1·5 per cent. of mercury.
(*b*) An experimental dust containing 1·5 per cent. of mercury.
(*c*) A dust containing 1·5 per cent. of mercury as ethyl mercury phosphate.

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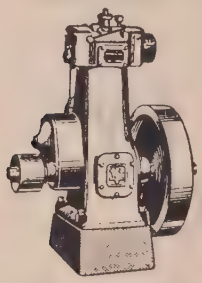

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(*d*) A dust containing 1·0 per cent. of mercury as ethyl mercury phosphate.
(*e*) An experimental dust containing 1·5 per cent. of mercury, including a small amount (0·15 per cent.) as ethyl mercury phosphate.
(*f*) Agrosan, a commercial dust containing 1·5 per cent. of mercury.
(*g*) An experimental dust, the active principle of which is a sulphur-containing organic compound.
(*h*) A mixture of cuprous oxide and talc.
(*i*) Copper carbonate.
(*j*) Undusted.

The unit plot was a 100-seed row, hand planted in the field. All possible combinations of times of storage, temperatures of storage, and dusts were included; the whole being replicated four times, making 800 rows in all. These were arranged as a factorial trial, so that the significance of the comparisons involved could be determined by Fisher's "z" test. Field germination was chosen in preference to germination in a laboratory incubator as the results are more nearly applicable to farming conditions.

Results.

Summaries of the results which satisfy the "z" test are given in Tables 1 and 2.

TABLE 1.

Mean percentage germination of Ranee wheat stored in contact with fungicidal dusts for various periods. (Mean of all storage temperatures.)

Stored.	Dusts.									
	(*a*)	(*b*)	(*c*)	(*d*)	(*e*)	(*f*)	(*g*)	(*h*)	(*i*)	(*j*)
0 weeks	62·6	80·5	74·6	81·0	73·1	73·1	73·9	78·5	64·0	65·4
2 weeks	74·4	71·8	71·7	75·3	75·1	74·3	76·1	78·1	79·0	66·0
4 weeks	75·6	77·5	65·8	75·0	74·2	68·1	76·0	78·7	78·6	72·1
6 weeks	77·9	77·4	62·4	73·1	70·3	69·4	75·4	77·1	73·4	71·3
8 weeks	75·1	67·2	62·8	68·9	73·4	70·4	66·4	72·0	71·8	68·6

Difference for significance at 5 per cent. level (S.E. × 3) = 10·5.

TABLE 2.

Mean percentage germination of Ranee wheat stored in contact with fungicidal dusts at various temperatures. (Mean of all storage times.)

Stored at	Dusts.									
	(*a*)	(*b*)	(*c*)	(*d*)	(*e*)	(*f*)	(*g*)	(*h*)	(*i*)	(*j*)
0° C.	69·4	73·4	77·7	82·3	75·6	66·0	73·3	79·5	71·9	64·0
10° C.	75·8	73·3	79·6	76·6	72·5	75·5	79·2	73·2	76·5	71·3
20° C.	75·2	74·2	58·6	70·8	70·4	68·8	71·0	74·3	72·7	73·9
30° C	74·6	76·6	54·1	69·1	74·5	73·9	70·8	80·6	70·9	65·5

Difference for significance at 5 per cent. level (S.E. × 3) = 7·6.

From the above results the following conclusions can be drawn: Undusted grain, stored in closed containers, either at 0° C. or 30° C. showed a significantly lower germination than undusted grain stored at 20° C. The effects of the dusts were:

(*a*) *Dusts with ethyl mercury phosphate as the active principle* (*c*, *d* and *e* (in part)). Without storage, dust (*d*) containing 1 per cent. of mercury as ethyl mercury phosphate (Hg. as E.M.P.) improved the percentage germination by a significant amount. Although both the other dusts affected germination in the same direction the improvement was not statistically significant.

Storage of treated seed reduced the percentage germination where dusts (*c*) (1·5 per cent. Hg. as E.M.P.) and (*d*) (1·0 per cent. Hg. as E.M.P.) were used. This reduction of germination was more rapid at the higher concentration of ethyl mercury phosphate. The temperature of storage was an important factor in this deterioration. When stored at 20° C. or higher, dusts (*c*) and (*d*) both reduced germination below that of similarly treated grain stored at 0° C. Unlike (*c*) (1·5 per cent. Hg as E.M.P.), dust (*d*) (1·0 per cent. E.M.P.) did not reduce germination below the undusted control, although storage at or above 20° C. for two weeks or longer nullified the improvement in germination, brought about by the application of this dust to wheat sown when dusted, or stored at 0-10° C.

(*b*) *Other organic mercurial dusts.* Dust (*a*), when applied to wheat and planted on the day of dusting, did not increase germination. Improvement occurred with storage and from the data it appears that the improvement is greater with temperatures at 10° C. or higher. The differences are not significant.

Dust (*b*), when applied to wheat planted immediately after dusting improved germination. This improvement was significantly reduced on storage, but, unlike the dusts containing ethyl mercury phosphate, the reduction was independent of the temperature of storage.

(*c*) *Non-mercurial dusts.* The cuprous oxide dust (*h*) significantly improved germination of wheat sown on the day it was dusted and in this respect it contrasted with the copper carbonate used. After two weeks' storage, however, both dusts behaved similarly, being significantly better than untreated grain.

Implication of Results.

In Australia a large amount of seed wheat is graded and dusted on a contract basis. This grain may be stored for some months before being planted. During this time mean monthly temperatures in excess of 20° C. may be experienced for 4-5 successive months, and it is clear that dusts of the type (*c*), and to a less extent (*d*) and (*b*), are unsuitable as commercial grain pickles.

The injury on storage is a factor to be considered in evaluating any newly introduced mercurial fungicides, and it is suggested that in testing new materials as fungicides attention be given to the effects on field germination. For this purpose a field germination test is recommended in which dusted grain stored for 8 weeks at 30° C. is compared with (i) undusted, and (ii) freshly dusted grain.

II. THE INFLUENCE OF TEMPERATURE AND TIME OF STORAGE ON THE GERMINATION OF BARLEY.

When the results of the experiment with wheat became known, an experiment was planned to determine whether any of the mercurial dusts had the effect of depressing the germination of barley stored in contact with them. Only those dusts likely to be of practical value for the control of barley diseases were included. A dust containing a growth hormone, β indolyl acetic acid, in addition to ethyl mercury phosphate, was included, to determine whether this substance would reduce any injurious effect of ethyl mercury phosphate on germination. Barley, of the variety Californian Cape, treated with the dusts listed below, was stored for periods of 0, 4, 8, and 12 weeks at 10° C., 20° C., and 30° C. The following dusts were all applied at the rate of 2 ounces per bushel :

(*a*) Agrosan
(*b*) Ceresan } commercial grain pickling dusts.

(*c*) An experimental dust, containing 1·5 per cent. of mercury. This is the same dust as labelled (*b*) in the wheat experiment.

(*d*) An experimental dust, containing 1·5 per cent. mercury, including 0·15 per cent. as ethyl mercury phosphate.

(*e*) A dust containing 1·0 per cent. mercury as ethyl mercury phosphate.
(*f*) A dust containing 1·0 per cent. mercury as ethyl mercury phosphate, to which β indolyl acetic acid had been added to give a concentration of 2·5 parts per million of the dry weight of the seed when dust was applied at the rate of 2 ounces per bushel.
(*g*) Undusted.

The unit plot was the 100-seed field row. The treatments were replicated six times, making 504 rows in all. These were arranged as a factorial trial, enabling the significance of comparisons to be made by Fisher's " z " test.

Results.

Summaries of the results appear in Tables 3 and 4.

TABLE 3.

Mean percentage germination of Californian Cape barley stored in contact with fungicidal dusts for different periods. (Mean of all storage temperatures.)

Stored.	Dusts.						
	(*a*)	(*b*)	(*c*)	(*d*)	(*e*)	(*f*)	(*g*)
0 weeks ..	82·9	84·8	77·4	79·8	81·1	80·9	82·7
4 weeks ..	81·0	81·1	84·8	83·5	83·0	84·4	83·7
8 weeks ..	84·2	82·2	84·4	85·5	83·3	84·0	83·4
12 weeks ..	86·1	85·3	82·6	82·4	82·7	85·8	80·2

Difference for significance at 5 per cent. level (S.E. × 3) = 4·38.

TABLE 4.

Mean percentage germination of Californian Cape barley stored in contact with fungicidal dusts at various temperatures. (Mean of all storage periods.)

Stored at	Dusts.						
	(*a*)	(*b*)	(*c*)	(*d*)	(*e*)	(*f*)	(*g*)
10° C. ..	83·5	83·0	80·0	81·9	82·2	83·5	81·8
20° C. ..	82·9	86·5	81·7	83·8	83·4	84·8	83·9
30° C. ..	84·2	80·8	85·2	82·7	81·9	83·1	81·8

The differences are not significant.

In contrast to the results obtained with wheat, none of the dusts examined caused a depression of germination, even when stored for twelve weeks at 30° C. All the dusts included, except (*b*) a commercial dust, and (*e*) containing 1 per cent. of mercury as ethyl mercury phosphate, significantly improved germination on storage.

The work described in this paper was done at the Waite Institute in consultation with Dr. I. F. Phipps and Mr. D. B. Adam. Thanks are given to Messrs. Imperial Chemical Industries, Ltd., for permission to publish the work, which deals with experimental dusts supplied by them.

Summary.

Experiments were conducted in which seed grain of wheat and of barley were stored in closed containers in contact with fungicidal dusts. No injurious effect on germination was observed when barley was stored with any of the dusts used, although the dust most injurious to wheat on storage was excluded from the barley trial. The germination of seed wheat was improved by treatment with the majority of dusts, but certain dusts, more especially those containing ethyl mercury phosphate as the active principle, caused a depression of germination on storage at 20° C. or higher. This depression of germination was serious, amounting to 25 per cent. in one case.

(Received for publication, 25th September, 1941.)

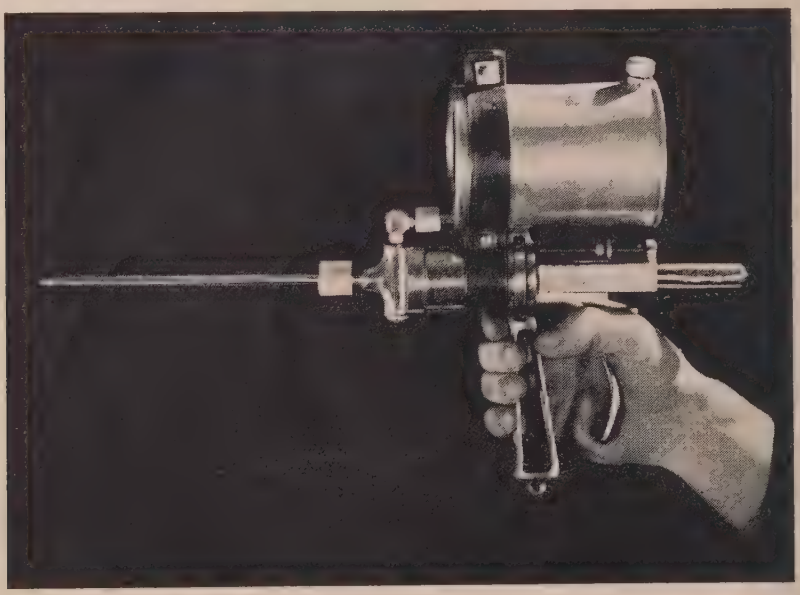
TECHNICAL NOTES

AN INJECTOR FOR LIQUID FUMIGANTS.

The injector illustrated below was designed to introduce small measured doses of carbon disulphide into bagged wheat in weevil control operations. The basis is a standard sheep-drenching gun. This delivers a measured dose between 0-30 mils at each depression of the plunger ; the amount is regulated by a lock-nut above the plunger. A nozzle $6\frac{1}{2}$ inches long, of $\frac{1}{8}$-inch bore stainless steel tube (which is stronger than mild steel) was fitted in place of the usual drenching nozzle. The point was turned separately ; it is detachable for cleaning, and has four apertures $\frac{3}{32}$-inch in diameter about half an inch behind the tip. It has been found not to clog in practice.

Carbon disulphide attacks rubber and synthetic rubber, and creeps through ordinary types of flexible spiral metal tubing. This makes the usual feed for this kind of gun, from a knapsack reservoir, impracticable. A container of 600 mils capacity was therefore attached as shown in the accompanying photograph ; a spring valve was fitted in the metal inlet cap. In some guns rubber piston washers are used ; these should be replaced by leather washers.

The injector is well balanced ; it can be pushed readily into bagged wheat under stack pressure. It should be useful for small-scale routine fumigation work by an untrained operator, as it can be relied on to give the predetermined dose. Some attention may be necessary to the packing of the plunger to avoid leakage at this point. Other possible applications of the injector might be in small-scale soil fumigation, as in pots in greenhouses ; it might also be used with other liquid fumigants such as ethyl formate (eranol) in treating, for example, foodstuffs in bales or packages.



We are indebted to Mr. A. D. Cocks of this Institute for suggesting the use of the drenching gun for this purpose, and for making the photograph.

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A SIMPLIFIED PHOTOELECTRIC CELL METHOD FOR MEASURING LEAF AREAS.

The photoelectric cell has often been employed in the measurement of leaf areas because of the rapidity and accuracy with which the measurements can be made. Many of the methods described, however, are expensive, difficult to construct, or suffer from other disadvantages, such as the use of a light source of high intensity which allows the transmission of a certain proportion of light through the leaves. A simple and inexpensive modification of the low light intensity device described by Hibbard *et al.* (Papers Michigan Acad. Sci. Arts and Letters, 23 : 141-147, 1937) has been used for the measurement of flax leaves and found to be very satisfactory.

The apparatus consists essentially of an illuminator, fully described in the above paper, at the base of which are placed 21 torch-light bulbs, equally spaced to give an even illumination. Seven groups of three bulbs, connected in series, are wired in parallel. A cone of polished tin, having a photoelectric cell at its apex, rests above the illuminating box. Between the cone and the box, two circular pieces of ground glass are placed for holding the leaves. In place of the more complicated lighting and recording method used by Hibbard *et al.*, the illuminator is connected to the main current supply through a transformer delivering 10 volts from a 240 A.C. main, a variable rheostat (0 to 6 ohms) being placed in the circuit. Leads run from the photoelectric cell directly to a galvanometer. The galvanometer should allow as great a deflection as possible—a Cambridge instrument of resistance 828 ohms and graduated from 0 to 120 was found to be quite satisfactory.

The apparatus can be calibrated by plotting the galvanometer deflections of known areas of black paper interposed between the glass plates against the areas. The light intensity should be first adjusted to give as high a reading as convenient on the galvanometer scale when no paper or leaves are interposed and it must be kept constant by means of the rheostat. The determination of leaf areas is then very rapid, it being necessary only to note the deflection and to read off the area from the graph.

Areas of paper approximating the mean area of individual leaves of the plant, of which the leaf area is to be determined, should be used in calibration. As no differences were found between the deflections caused by " units " of 2 sq. cms. and 16 sq. cms. at total areas of 16, 48, and 80 sq. cms, it should only be necessary therefore to calibrate again, if the individual leaf of a plant of which the area is to be determined, differs very widely from that of the plant for which the apparatus was calibrated.

No transmission of light takes place through the leaves, the source being of too low an intensity. Thus corrections for transmission are avoided, and the use of black paper in calibration is quite justified.

The apparatus should be turned on for 20 to 30 minutes before being used to allow the transformer to heat sufficiently—otherwise a steady downward drift occurs—and the constancy of the intensity of the light source should be checked from time to time. When these precautions were taken, the accuracy of the apparatus was shown by the measurement of total leaf areas of 16, 48 and 80 sq. cms., which, when measured with individual areas of 2 sq. cms. gave coefficients of variability of 2·07, 2·22 and 2·60 per cent. respectively, and when measured with individual areas of 16 sq. cms. gave coefficients of variability of 2·41, 2·71 and 3·04 respectively. Each value was the result of 10 readings, made at different times.

The apparatus was constructed by Mr. R. Tupper, Botany School, Sydney University, to whom sincere thanks are due.

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FACTORS INFLUENCING ACID PRODUCTION BY LACTIC ACID STREPTOCOCCI IN MILK AND CHEESE CURD.

The literature contains numerous accounts of investigations to determine the effect of various factors on the growth of the lactic acid bacteria. Studies on the effect of temperature of incubation and the associative growth of other bacteria have been made, but most of them were concerned with the growth of the lactic acid streptococci in milk which was not handled under conditions closely resembling those encountered in the conversion of milk into cheese curd. Most attention has been directed to those factors affecting the final acidity and not, as in the experimental work covered by this investigation, to the rate of growth as reflected by determinations of acidity at appropriate intervals throughout the experiment. It will be appreciated that the final effect of any factor governing the normal development of the lactic streptococci in milk incubated at a constant temperature may differ from its effect in milk and curd in the various stages of the cheese making process.

The object of the investigation was to determine the influence of various factors on the rate of acid production by starter streptococci in milk incubated at a constant temperature, and, in appropriate instances, under conditions comparable with those encountered in the cheese vat. For the latter purpose a modification of the vitality test devised by Whitehead and Cox* was used.

Observations were made concerning

(1) The effect of various methods of heating milk upon starter streptococci.
(2) The effect of management on starters: (*a*) amount of inoculum, (*b*) shape of vessel, (*c*) stirring, (*d*) cooling, (*e*) degree of acidity when transplanted, (*f*) temperature of incubation.
(3) The effect of associative growth of starter streptococci with (*a*) *Bact. coli*, (*b*) *Bact. ærogenes*, (*c*) Sarcina, (*d*) *B. subtilis*, (*e*) "inhibitory streptococci".
(4) The effect of pathological and physiologically abnormal milk: (*a*) mastitis milk, (*b*) late lactation milk, (*c*) colostrum.
(5) The effect of gases: (*a*) aeration (air).

Pure cultures of single strains of *Streptococcus lactis* and *Streptococcus cremoris* and mixed cultures of these two organisms were used, as the starters sent out from various laboratories contain either single strains or several species. The organisms had been cultivated in the laboratory for many generations prior to their use in these experiments. They were subcultured daily in test tubes containing sterile separated milk and incubated at 22° C.

It is not possible within the compass of this summary to include the details of the actual experimental data, but the influence of various factors on the rate of acid production in milk and in cheese curd by the lactic acid streptococci typical of starters may be summarised:

(*a*) Acid is formed fastest at 37° C. in the early stages of fermentation, but later at 32° C. At other temperatures the development varies in the order 28° C., 22° C., and 15° C.

(*b*) Acid is formed almost as rapidly in milk heated momentarily to 76·7° C. (170° F.) as at higher temperatures and for longer exposures, but there is a slower rate of fermentation in milk heated to 62·8° C. (145° F.) for 30 minutes and in unheated fresh milk.

(*c*) The rate of acid production is proportional to the quantity of inoculum.

(*d*) The shape of the containing vessels has no significant influence.

(*e*) The amount of stirring normally received by milk is without effect.

(*f*) When transplanted into milk incubated at a constant and favourable temperature and into milk handled under the conditions obtaining in the cheese vat, the rate of acid formation by starters varying from 0·6 to 0·9 per cent. acidity does

* Whitehead, H. R., and Cox, G. A.: N.Z. J. Sci. and Technol., 13: 304, 1932.

not differ significantly. There appears, therefore, to be no advantage in cooling a coagulated culture. Prolonged cooling, or over-ripening, does, however, retard the subsequent activity.

(*g*) *Bact. coli* and *Bact. aerogenes*, in higher numbers than ordinarily encountered as contaminants in milk, are practically without effect. If extensive multiplication of these organisms has occurred before adding the starter, they inhibit the rate of acid formation by the starter in the later stages of fermentation. Sarcina has no effect. Milk in which *B. subtilis* is actively growing stimulates acid formation by lactic streptococci at low temperatures, but at the comparatively high temperatures in the cheese vat the influence of this organism is inappreciable. The production of acid is seriously restrained in milk in which " inhibitory streptococci " have developed.

(*h*) The development of starters in mastitis milk is sometimes strongly checked and, after pasteurisation, such milk may still prevent normal acid formation.

(*i*) The rate of fermentation by lactic streptococci is slower in late lactation than in full lactation milk.

(*j*) Acid formation is slightly more rapid in milk to which colostrum to the extent of 10 to 25 per cent. is added, than in normal milk.

(*k*) Aeration retards the development of acidity in milk incubated at a constant temperature, but its influence in milk submitted to the vitality test is slight.

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A NOTE ON " PERENNIAL " PRAIRIE GRASS.

In a previous paper[1] the results of investigations into strain variation in prairie grass (*Bromus unioloides* H.B. et K.) were reported. Material of this voluntarily self-pollinated species received from Australian and overseas sources was studied under single plant conditions and in grazed swards. Eight types were recognised. The material of Type VI gave the highest yields of the eight types in grazing trials both at the Waite Research Institute, Adelaide (rainfall=22·5 in.) and on an irrigated reclaimed swamp at Murray Bridge, South Australia. In addition, all material of this type showed a complete immunity from infection by *Ustilago bromivora* (Tul.) F. v. W., which frequently reduces or prevents seed production in prairie grass.

In May, 1939, the work was continued by the laying down at the Waite Research Institute of a further sward trial to compare the relative yields of the five lines of prairie grass which had been classed in Type VI. These lines were sown in plots of 1/250 acre in five randomised blocks. Sowing was at the rate of 6·25 seeds per square link, giving a mean seed rate of 15 lbs. per acre, depending on seed size. Subterranean clover at 6 lbs. per acre and superphosphate at 2 cwt. per acre were common to all plots. Two samples of $5 \times 2\frac{1}{2}$ square links were cut from each plot before grazing, and the yield of prairie grass was determined by hand separation and weighing. Only one cut was secured in the seeding year (1939), and in the exceptionally dry season of 1940, yields were very low. The yields are given in Table I.

Treatment differences as a whole were not significant for the 1939 or 1940 seasons, nor for the combined yields for the two seasons. A weighted total, to which each of the two seasons contributed equally effectively, was obtained for each

plot by adding to the yield obtained for the 1939 season, the 1940 yield for the same plot multiplied by $\sqrt{\frac{\text{Total variance 1939}}{\text{Total variance 1940}}}$. These totals were analysed, and treatment differences were significant at approximately 6 per cent. Thanks are due to Mr. G. A. McIntyre, of the Biometrics Section, C.S.I.R., for suggesting this procedure.

" Perennial " prairie grass gave the highest yield in each season, though its superiority over most of the other lines of Type VI was not statistically significant. In each of the two previous sward trials (in which all eight types were tested) " perennial " prairie grass gave significantly greater yields than the other nine lines tested with it.[1] Thus it may be stated that on the basis of sward trials conducted at the Waite Institute and on the Murray Swamps during the period 1937-1940, " perennial " prairie grass is the most valuable of the wide range of material of *Bromus unioloides* collected at the Waite Institute. It is vigorous, high yielding, and is immune from smut infection. In 1940, 1,000 plants of " perennial " prairie grass showed no smut infestation following heavy seed inoculation. Susceptible lines showed 100% infection under the same conditions. This confirmed previous smut inoculation tests.[1] The prefix " perennial " to the name of this strain is not justified, for like all material of the species examined, it is of weak perenniality.

TABLE 1.

Yield of Five Lines of Prairie Grass of Type VI.

Origin of Material.	Cwt. dry matter per acre.			
	1939.	1940.	Total.	Weighted Total.
Jervois Swamp, S.A.	15·01	2·23	17·24	25·46
Burdett Swamp, S.A.	22·00	3·39	22·39	37·84
New Zealand	21·61	3·95	25·56	40·07
Argentine	17·72	4·15	21·87	37·14
" Perennial " Prairie Grass ..	23·76	5·77	29·53	50·74
S.E.	—	—	—	*5·31*

" Perennial " prairie grass was selected from material of unknown origin at the New England Experiment Farm, New South Wales.[2] It was handed over to seedsmen some ten years ago, and the seed has been produced on a commercial scale in Tasmania since that date. A price about 150% in excess of that for ordinary prairie grass is charged for " perennial " prairie grass, though it sets seed with equal freedom. It is not known whether the line has remained free from contamination throughout the period of commercial production, and the above description of vigour and immunity from smut infection applies strictly only to the six samples received at the Waite Institute in 1934 and 1935. It is suggested that the misnomer " perennial " prairie grass should be replaced by some such name as New England prairie grass. Although this strain is the most valuable agronomic form available in Australia at present, it is possible that a better type could be produced by hybridisation.

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GERMINATION OF SEED OF CURLY MITCHELL GRASS (*ASTREBLA LAPPACEA* DOMIN.).

In view of the recent trend toward the regeneration of the north-western grazing areas of this State by sowing seed of native species, the results of some studies on germination of *Astrebla lappacea* should prove of value. The work included tests to establish optimum conditions for the laboratory germination of mature seed, an analysis of commercial " seed " for its caryopsis content, the germination of maturing seed, and the effect of potassium nitrate as an artificial stimulant of dormant seed.

Effect of Temperature and Light on Germination of Mature Seed.

Seed, 18 months old, harvested on the property of Mr. L. T. Seccombe, Rowena, was used in these tests. Four hundred seeds were tested at each temperature, 200 being exposed to light and 200 covered with blotting paper. All seeds were surface sterilised with mercuric chloride (0·001 per cent.).

Four alternating temperatures were selected, viz. 20°–32° C., 32°–20° C., 35°–16° C., 35°–32° C., and three constant temperatures, viz. 16° C., 20° C. and 32° C. The alternation, 35°–32° C., was the highest temperature available at that time in the laboratory. In each case, the first figure of the alternations was maintained for 16 hours, and the second for 8 hours daily.

The lowest temperature, 16° C. constant, definitely retarded germination. At 20° C., though germination during the first week was retarded, unexpectedly high final results were obtained. There was no advantage gained by using any of the alternating temperatures, 32° C. constant being near the optimum of the range tested. Analysis of the percentage figures, without transformation, indicated that a constant temperature of 32° C. was better than constant temperatures of either 20° C. or 16° C.

Counts made during the period of testing indicated that satisfactory results could be obtained after 17 days as compared with the minimum of three weeks necessary in the case of dormant seed.

Germination was affected little either by light or darkness.

Distribution of Caryopses in Spikelets.

Commercial curly mitchell grass " seed " consists of spikelets bearing a variable number of flowers. The number of seedlings produced by any spikelet therefore varies with the number of caryopses it bears. In the laboratory, though one spikelet may produce more than one seedling, it is counted as one " seed " germinating, and since it is impossible to select seed capable of germination, the interpretation of results of germination tests is thereby restricted.

TABLE 1.

Distribution of Caryopses in Spikelets of Astrebla lappacea.

Sample.	Number of Caryopses per Spikelet.							Mean.
	0	1	2	3	4	5	6	
1 (100 spikelets)	3	23	19	27	19	7	2	2·65
2 ,, ,,	9	18	22	29	19	2	1	2·41
3 ,, ,,	16	18	22	25	18	1	0	2·12
4 ,, ,,	16	20	16	29	13	6	0	2·21

The " seed " used in this analysis, and in the germination tests described below, was harvested on the property of Mr. Noel Barrett, Edgeroi, in June, 1939.

The analysis of 400 spikelets, in four lots of 100 each, given in Table 1, shows the variation in the number of caryopses per spikelet.

Germination of Maturing Seed.

Samples were germinated after various periods of storage in a tin container which, however, was not completely airtight owing to the necessity for opening the tin at frequent intervals. Tests were made one, two, three and four weeks after harvest ; then six, eight, ten and twelve weeks ; then at monthly intervals for the succeeding nine months ; and finally when the seed was two years old. It is proposed to continue these tests till results show that the seed is no longer viable.

Four hundred seeds were tested at each period, 200 being exposed to light and 200 covered with blotting paper. All tests were made at 32° C. and all seeds were surface sterilised.

That mitchell grass has an after-ripening period was shown by the increase in germination during the 12 months after harvest. This maturation was apparently completed in that time since there was no increase during the following year, though viability was unimpaired by storage.

It was found again that almost identical germination was obtained in light and in darkness, and consequently the figures have been averaged in presentation of results in Table 2.

TABLE 2.

Percentage Germination of Seed of Astrebla lappacea *after Storage (Months).*

Immediately after Harvest.	1	2	3	4	5	6	7	8	9	10	11	12	18	24
31·0	40·0	52·5	42·5	45·0	62·5	55·5	67·0	67·5	77·5	71·5	77·0	83·5	74·0	85·0

Effect of Potassium Nitrate on Germination of Dormant Seeds.

It has been established in many laboratories that the germination of dormant seed of some species may be stimulated by using a potassium nitrate solution, instead of water, to moisten the germination pad. The use of such a stimulant is usually more effective in the absence of light.

Potassium nitrate (0·2 per cent.) was used on seeds from the same lot as the previous series. The number of seeds tested, and other conditions were replicated. The first results, with seeds two weeks old, showed some response to the treatment, but by the time the seed was three weeks old there was no difference between the treated and control lots.

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SYMPTOMS OF ZINC DEFICIENCY IN WHEAT AND FLAX.

As a result of the improved growth which has been induced in cereals, flax and clovers grown on black soil of the Wimmera district of Victoria by the incorporation of small amounts of zinc sulphate with the usual superphosphate application,[2, 3, 4] the question arises whether plants grown in such soil without the application of zinc exhibit any specific symptoms of zinc deficiency.

Symptoms of zinc deficiency have, therefore, been produced in wheat and flax grown in water cultures at the Plant Research Laboratory, Burnley. The solution employed was that of Arnon,[1] the main constituents of which were purified by Stout and Arnon's[7] modification of Steinberg's[6] technique. Double distilled water produced by a pyrex glass still was used, and the plants were grown in two-litre pyrex glass beakers blackened on the outside and covered with plaster of Paris tops soaked in paraffin. Free Gallipoli wheat and Liral Crown flax were the varieties selected for the experiments. As soon as possible after germination in acid-washed sand, eight seedlings were transferred to each beaker. In most instances, four wheat and four flax plants were grown in the same container. In one series, however, the wheat and flax plants were set up in separate beakers.

The following are the symptoms of zinc deficiency which developed.

The Free Gallipoli wheat plants developed symptoms very similar to those of zinc deficiency of oats, which have been produced in water culture by Piper.[5] Within three to four weeks after setting up the water cultures, the plants were not as tall as the controls, tillering was reduced, and the youngest leaves became a paler green than normal. Within a few days, irregular, opaque, greyish-green, collapsed spots appeared on these leaves. Although these spots ultimately extended until a considerable area of the distal half of the leaf was involved, they usually first appeared about the centre of the leaf, which characteristically developed a sharp bend at this point. These spots soon dried out and became light brown or whitish in colour. The remainder of the leaf finally died. Growth became very restricted and leaves formed subsequently were small and chlorotic. They soon developed the characteristic symptoms on the upper half of the leaf. In these later-formed leaves, the tip was often the first part of the leaf to show the spots. The plants failed to develop beyond the seedling stage, whereas the control plants were approximately four feet high at the end of the experiment.

The leaf symptoms described above have not been observed on cereals growing on Wimmera black soil, even though considerable improvement in growth and yield may result from the application of zinc sulphate. The plants treated with zinc, however, are characteristically darker green in colour than the untreated plants. The description of the condition termed "Grey leaf" of oats by Turner and Findley[8] is very similar to that of zinc deficiency. It was only shown, however, that "grey-leaf" was not amenable to dressings of manganese salts.

Liral Crown flax plants, growing in the same container as wheat seedlings, usually developed characteristic symptoms approximately one week before the wheat plants. It would seem that the zinc requirement of flax is greater than that of wheat. In this regard, it has been observed in the field that a relatively greater improvement in growth may result from the application of zinc sulphate to flax grown on Wimmera black soil than to wheat.[2] Within two to three weeks, growth of the plants in the water cultures became noticeably checked, and soon afterwards greyish-brown, collapsed spots appeared in the centre or on the lower half of the youngest leaves. The spots were most marked on the upper surface of the leaf. On the under-surface they appeared as dark green blotches. These lesions soon dried and became light-brown to white in colour. The spots on later-formed leaves were bronze in colour. Bronze spots also occur on the leaves of potato plants suffering from zinc deficiency.[9] In some instances, the above leaf symptoms were preceded by the development of a small bronze-coloured spot on the under-side of

Figure 1.

Figure 2.

Figure 3.

Figure 1.—Zinc deficiency symptoms on upper half of leaf of Free Gallipoli wheat plant grown in zinc-free nutrient solution.

Figure 2.—First symptoms of zinc deficiency of Liral Crown flax plants grown in zinc-free nutrient solution. Photographed about seven days after symptoms first appeared. Dark grey to brown collapsed spots occur on the lower half of the younger leaves.

Figure 3.—Liral Crown flax plant grown in water culture deficient in zinc. Death of the main stem has occurred and bronze-coloured spots occur on the leaves of the secondary shoots produced from the base of the plant.

the petiole at the point where it joined the main stem. The main stem in close proximity to the affected leaves developed a rusty brown discoloration, and very little growth occurred above the affected area.

The internodes between leaves became very short, giving the top of the plant a rosetted appearance. Later the top of the main stem became necrotic and all the lower leaves dried from the tips downwards, although the stem itself remained green for some time afterwards. Meanwhile, the plants produced secondary shoots from the base, which soon developed bronze-coloured spots on the leaves, followed by necrosis of the leaves from the tip. Finally the whole plant died. Where zinc was applied before the symptoms became too severe, the plant resumed its normal growth. Similar symptoms to the above have been observed in Liral Crown flax plants growing in the field in Wimmera black soil. Growth is restricted, bronze-coloured spots appear on the leaves, necrosis of the tip of the main stem occurs, and secondary shoots, which also develop characteristic symptoms, are produced from the bottom.

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INSECT TRANSMISSION OF WALLABY EAR DISEASE OF MAIZE.

Late planted maize in many districts in south-east Queensland is affected by a disease, known locally as Wallaby Ear, which has not been reported to the writer's knowledge as occurring in any other part of the world. The first symptoms are usually seen towards the end of January. Maize which is fully grown at this time suffers little, while crops which have just been planted may become a total loss. The first symptoms are small swellings on the secondary veins on the undersides of the top leaves. These symptoms are suggestive of Fiji disease of sugar cane. In young maize the veins rapidly become swollen from the tip of the leaf to the sheath, the plant is dwarfed and abnormally deep green, pollen yield is reduced, silk growth slow, and the cobs and grain are much retarded in growth (see Fig. 1).

As it occurs at the hottest part of the season, which may be very dry or very wet, the disease has been ascribed to drought or to wet feet. Observations were made at Lawes, Queensland, in 1940 and it was found that in the early stages of the disease the jassid *Cicadula bimaculata* Evans was rapidly multiplying in the field until at the maximum onset of the disease this insect was present in vast numbers. No signs of a pathogenic fungus were evident and the manner of spread of the disease through the crop suggested that an insect was responsible. Earlier experiments and observations indicated that the disease was not easily, if at all, transmissible by mechanical means, and no X-bodies were found. The theory that the disease had an insect vector was tested in 1941.

Ten insect-proof cages were erected in the field at the time of the maximum onset of the disease, with about twenty plants of a susceptible single cross hybrid and five plants of a resistant single cross in each cage. General resistance observations had been made in the field in the 1939-40 season. Four control cages were kept free of insects, three for 47 days, one for 26 days. Adults and nymphs of the jassid under suspicion (*Cicadula bimaculata*) were taken off diseased plants and tried in seven cages; another prevalent jassid, *Peregrinus maidis* Ash., was included in the trial mixed with *Cicadula bimaculata* in four of the above cages and alone in one other cage.

The results are given in Table I. In four out of five cages exposed to *C. bimaculata* and *P. maidis* the disease had developed in about three weeks; in two cages exposed to *C. bimaculata* alone, the disease developed in about the same time, while in one cage exposed to *P. maidis* alone the disease failed to develop in 18 days' exposure after which *C. bimaculata* was introduced. No control plants in any of the four cages developed the disease. This trial conclusively proves that the vectors of Wallaby Ear are jassids which are prevalent after mid-summer. The results indicate that *Cicadula bimaculata* is mainly responsible for carrying the disease, which is probably a virus.

Figure 1.
Maize plant showing typical symptoms of Wallaby Ear disease. The plant is 2 feet high, 8 weeks old and completely sterile.

TABLE I.

Observations on the Development of Wallaby Ear Disease in Cages Infested with C. bimaculata *and* P. maidis *alone and in Combination.*

Treatment.	Cage No.	Days Exposed.	Days taken for Development of		Remarks.
			First Symptoms.	Severe Symptoms.	
Control	3	47	—	—	No disease developed.
	6	47	—	—	,, ,, ,,
	9	47	—	—	,, ,, ,,
	10	26	—	—	*C. bimaculata* added after 26 days (see Cage 10B)
C. bimaculata alone	2	—	—	—	Seedlings eaten by cutworms and replanted after 17 days (see Cage 2B).
	2B	30	14	30	
	10B	19	—	19	
P. maidis alone ..	5	18	—	—	*C. bimaculata* added after 18 days (see Cage 5B).
C. bimaculata and *P. maidis* ..	1	47	—	16	
	4	47	—	16	
	7	47	14	24	
	8	47	17	24	
	5B	23	—	—	

As the best means of preventing most virus diseases of farm fodder crops is the use of resistant varieties, it is encouraging to observe that hybrid maize strains show varying degrees of resistance, which can be related to some of their parent inbred lines. A fair degree of resistance has been observed at present, but it is hoped that further experiments will produce inbred lines of increased resistance and will throw some light on the genetics and perhaps also on the physiological nature of resistance.

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The Australian Institute of Agricultural Science

FOURTH GENERAL MEETING.

The fourth general meeting of the Institute was held on 11th November, 1941, at the School of Agriculture, the University of Melbourne. As the Council had decided that the times and circumstances were inappropriate for the usual type of meeting, the report of Council, which was published in last issue of this Journal, was adopted and the other business was briefly transacted. Professor J. A. Prescott was unanimously re-elected as President of the Institute.

MEETING OF COUNCIL.

At the meeting of Council held on 8th December, at the School of Agriculture, Melbourne University, the following officers were appointed : Hon. General Treasurer, Mr. R. L. Twentyman ; Hon. General Secretary, Mr. A. J. Vasey ; Hon. Assistant Secretary, Mr. R. D. Croll ; Editor of Journal, Dr. F. T. Bowman ; Business Manager of Journal, Dr. N. S. Noble ; Publications Committee, Dr. H. J. Hynes (Chairman), the Editor and Business Manager of the Journal, Dr. E. T. Edwards, Mr. F. C. McCleery, Dr. I. A. Watson.

On the advice of the N.S.W. Branch, Council approved of the discontinuance of the Agricultural Potentialities Survey being conducted by that Branch, in view of the intention of the Department of Agriculture, N.S.W., to proceed with an official survey. Mr. F. Melville was admitted to membership of the Institute. The balance at bank as at 8th December was recorded as £228 8s. 1d.

MEETINGS OF BRANCHES.

New South Wales Branch.

The seventh annual general meeting was held in Science House on 13th February, 1942, with an attendance of 29 members and 8 visitors. A presentation was made to Dr. H. J. Hynes, in appreciation of his services during the past seven years as Editor of the Journal, by the Branch President on behalf of the President and members of the Institute. The following officers were elected for the ensuing year : President, Dr. H. J. Hynes ; Vice-President, Mr. R. N. McCulloch ; Hon. Treasurer, Mr. L. C. Holmes ; Hon. Secretary, Dr. S. L. Macindoe ; Committee of Management, Dr. F. T. Bowman, Mr. W. W. Jones, Mr. A. W. S. Moodie. The lengthy services of the retiring Secretary and Treasurer were acknowledged by the meeting. Dr. I. A. Watson was elected sub-editor for New South Wales.

In lieu of the usual address, the President introduced the subject " Agricultural Scientists and the War ". After Dr. R. J. Noble indicated the views and policy of the Department of Agriculture upon enlistments, several speakers dealt with divisions of the subject matter. Dr. E. T. Edwards spoke upon " the Manpower regulations and the war work done so far by agricultural scientists in the course of their professional duties." Mr. Moodie extended the discussion to war work which agricultural scientists might carry out either as members of the defence forces or as civilians. Following discussion, the furtherance of this work was referred to a committee

Dr. Macindoe spoke upon " the Reorganisation of Australian agriculture to meet war-time conditions ", and a committee was elected to report on the subject.

The meeting received a report on " Extension Services " from the joint committee of the N.S.W. Branch of the Institute and the N.S.W. Branch of the Australian Veterinary Association. The report was reserved for discussion at a later meeting, to be held jointly with the last named association.

Victorian Branch.

The main business of the general meeting held on 5th December, 1941, was the presidential address entitled " Victorian Horticulture—Today and Tomorrow ", delivered by Mr. F. M.

Read. This address, which had been delayed owing to the pressure of special official duties, is reported elsewhere in this issue.

Institute members attended a meeting of the Melbourne University Agricultural Society, held on 14th November, 1941, at which Miss E. A. Lindsay, B.Sc.Agr., M.S., who had just completed a two years' post-graduate course at the University of California, gave an illustrated address on " Some Aspects of American Agriculture ". Of particular interest was a movie film demonstrating a newly developed method of photographing the wing movement of insects in flight.

Queensland Branch.

The final meeting of 1941 was devoted to notes and exhibits, contributors being Mr. J. H. Smith, who spoke on " Clothes moths in wool ", Mr. C. G. Hughes on " Sugar cane seed, and stimulation of budding in cane sets ", Mr. C. W. Winders, " Kikuyu grass seed " and N. E. H. Caldwell on " Control of bronzy orange bug ".

Current Notes and News

The Agricultural Holdings Act, New South Wales, 1941.

The Agricultural Holdings Act assented to by the Legislative Assembly of New South Wales on the 13th November, 1941, is a notable addition to our agricultural legislation. Previous legislation of a similar character, namely the Rural Tenants Improvement Act, 1916, and the Agricultural Lessees Relief Act, 1931, which had failed to achieve the desired results, was repealed.

The system of farm tenancy prevailing in New South Wales for many years has caused the Department of Agriculture considerable concern. Many farm tenants and sharefarmers, in the absence of compensation for improvements and security of tenure, have been following an exploitative form of agriculture, the results of which are apparent in the low volume of business and the alarming evidence of declining soil fertility. Because of the restrictive conditions of their tenancies, many tenants have not adopted the modern methods advocated by extension workers. As approximately 36 per cent. of the dairy farms in coastal districts are in the hands of tenants and sharefarmers, the total area affected was extensive and the handicaps to extension workers were severe.

To survey the position and to formulate remedial measures, a committee consisting of Messrs. A. H. E. McDonald, Max Henry, O. C. Ballhausen, Directors of the Divisions of Plant Industry, Animal Industry and Dairying respectively, and A. W. S. Moodie, Senior Agrostologist, was appointed in August, 1940. It recommended educational activities as well as legislative action, and plans to implement these recommendations have been drawn up. The previous acts failed partly because they did not meet the circumstances adequately, and partly because farm operators were not informed and educated upon the value to them of those acts. Whether the Agricultural Holdings Act, 1941, will achieve the objects for which it has been designed will depend almost entirely upon the use made of it by the rural community.

This Act, which was modelled on the English Agricultural Holdings Act, 1923, is not a penal act. It confers upon tenants and sharefarmers certain rights, which include compensation for improvements carried out on the holding, a considerable degree of security of tenure, reference to an arbitration on the rent of the holding and freedom of action within certain limits regarding farm operations. The section dealing with the duration of tenancies marks a considerable advance on previous legislation. The extension of the provisions of the Act to sharefarmers should improve the conditions of these operators, who in many respects are in a similar position to tenant farmers, but have lacked any form of protection in the past.

The Act is designed to influence farming methods by the provision of compensation for the unexhausted value of fertilisers and green manure crops, for permanent and temporary pastures sown by the tenant, for the erection of subdivision fences and similar matters connected with farm operations.

Matters in dispute between landlords and tenants must be referred for decision to a district agricultural committee, which will consist of representatives of the parties concerned in the dispute and an independent chairman appointed by the Minister for Agriculture. Members of the legal profession are expressly forbidden to appear before agricultural committees.

Previous Acts were administered by the Department of Lands. This Act will be administered by the Department of Agriculture, by whose extension services the farming community will become quickly acquainted with the Act, its privileges and requirements. This will constitute an essential section of the educational campaign which it is planned to commence with the proclamation of the Act. Another aspect of this campaign will stress the social functions and responsibilities of agricultural land holding.

The principal object of the Department is to build up a system of land tenancy similar to that which has functioned successfully in Great Britain for many years under which the interests of soil, tenant, landlord, the community, and future generations are preserved.

Recent Work in Plant Genetics and Breeding.

At a recent meeting of the N.S.W. Branch of the Institute, Dr. I. A. Watson and Dr. S. L. Macindoe, lately returned from U.S.A., spoke upon Recent Developments in Plant Genetics and Breeding.

Dr. Watson discussed mainly three aspects of genetics, namely chromosome changes, chromosome maps and genes for disease resistance. It is now well established that genetic factors located on the chromosomes are largely concerned with the transmission of characters from generation to generation. Any process that can change the number of these factors or genes, or effect their chemical composition or even disturb the balance between them, is likely to produce a variation in the appearance of the plant. Such changes may be brought about in many ways, but the commonest are :

(1) By doubling the whole chromosome complement.
(2) By adding or deleting a whole chromosome to give $2n$ plus 1 and $2n$ minus 1 types respectively.
(3) By adding or deleting part of a chromosome to give duplications and deficiencies.
(4) By changing the relation between parts of chromosomes.
(5) By changing the composition of the individual gene.

Various methods have been utilised to obtain $4n$ types from the ordinary diploid. Colchicine and acenapthene are now used almost exclusively for this purpose ; but once accomplished, polyploidy is of questionable value to the plant breeder. X rays and ultra-violet light can produce this doubling effect, but they exert other influences as well.

Chromosome maps indicating the linkage relationships of important genes are useful in a plant breeding programme. Genetical and cytological methods can be used in their location in the chromosome. Backcrossing to the multiple recessive has become the most accurate and most popular genetical test. Trisomic ($2n$ plus 1) types giving tisomic ratios can be used for genetical tests, too. In maize, where the usual linkage testers are likely to predispose the plants to smut, translocations are useful in getting the linkage relationships.

The salivary gland chromosomes have been of great value in correlating genetical and cytological chromosome maps. In *Drosophila melanogaster* it has been found that deletions of certain bands in the X salivary gland chromosome are invariably associated with the loss of a normal allele for a particular character such as white eye.

In practical plant breeding it is necessary to know the number of, and the mode of action of the genes for disease resistance. Genes for resistance to disease are often associated with genes for undesirable agronomic characters. High resistance to stem rust in Hope wheat appears to be strongly linked with the susceptibility to a condition of stem blackening. Since disease reactions are at least three-phase phenomena, something must be known of the pathogen. Among the rust fungi certain key races are known, resistance to which automatically gives resistance to many others. An exact knowledge of the mode of inheritance of resistance to groups of physiologic races and to single races is a sound prerequisite to any breeding programme designed to obtain disease-resistant varieties.

Dr. S. L. Macindoe's contribution was upon applied genetics or plant breeding. Several recent contributions to methods of crop improvements have been largely the outcome of genetic philosophy confirmed by experimental, and frequently by statistical, data. Crops of little or no economic value may be used to establish genetic principles, but the gap between knowledge and its application might be reduced by the more frequent use of economically important crops in genetic investigations.

Methods of improvement of largely *self-pollinated* crops were exemplified firstly by wheat. The stem rust-resistant wheat Thatcher is grown on approximately 17½ million acres. Mature-plant and physiologic resistance to numerous races could, on the basis of genetic knowledge, now be speedily combined. The " backcross " method of breeding has been and could be used to produce varieties resistant but otherwise similar to the existing standard varieties. Stem rust-resistant winter wheats are being bred in U.S.A. in order to act as a barrier to the north and south movements of rust spores. A successful example of breeding for insect resistance is instanced in the case of the hessian fly. In oats, resistance to leaf and stem rusts and to smuts is possessed by new varieties. Genom analysis has helped to explain sterility and the occurrence of fatuoids and steraloids, and of speltoids in wheat. In barley, many new lines are resistant to diseases. Some unusual methods of breeding include the bulking and mixing of hybrid populations, the making of multiple crosses and the accessing of the combining ability of parents. Genetic maps are in process of being constructed. In sorghum, successive mutations for dwarfness, erectness, disease resistance, earliness and grain colour have resulted directly or indirectly in a rapid expansion into cooler and drier areas of grain sorghums harvested with the header.

Methods of improvement of largely *cross-pollinated* crops were exemplified by maize. Perhaps 90 per cent. of the area sown to corn in the corn belt States of U.S.A. is planted to hybrid maize, with an average increase over open-pollinated seed of 10-20 per cent. This progress is the outcome of suggestions made by " theoretical " geneticists. The maize breeders who are also geneticists

and statisticians, have made important contributions towards the following concepts : (1) the theory of heterosis ; (2) convergent improvement ; (3) the pedigree method of obtaining superior inbreds ; (4) the degree of correlations between characters of inbreds and their hybrid performance ; (5) the consideration of combining ability as an inheritable character ; (6) the testing of combining ability in early generations of selfing ; (7) the importance of genetic diversity in hybrid combinations ; (8) the influence on vigour of the rate at which homozygosity is reached ; (9) the prediction of double cross, and of synthetic variety yields.

American breeders are in the process of applying the above corn breeding principles to improvement of grasses and clovers. The suggestion that double cross yields could be predicted has been confirmed experimentally and the prediction of synthetic variety yields is now contemplated.

Correspondence

INTERNATIONAL COMPARISONS OF AGRICULTURAL PRODUCTIVITY

Editor,
A.I.A.S. Journal.

Sir,

In his recent book *The Conditions of Economic Progress*, Mr. Colin Clark gives approximate indices, calculated from the data available, of the agricultural and pastoral productivity per head of various countries. The index for Australia (1524) is second only to that of New Zealand (2444) and compares very favourably with U.S.A. (661), Canada (618) and Great Britain (475). If we were to base such a comparison on the " value of primary production ", gross or net, the difference in physical productivity would be distorted by the differences in local prices. In the September issue of this Journal (p. 92) Mr. J. A. Aird quoted figures to show that during the period in question (1925–34), the New Zealand prices of the most important products were generally lower than the Australian. Assuming for the moment that the figures used are appropriate, this would only show the necessity to use some standard price to obtain a true indication of relative productivity. In some cases the local prices have been kept above overseas prices by artificial marketing schemes. The relative prices of dairy products, in terms of butter fat, given by Mr. Aird, show the New Zealand price as lower than that for Australia. Certainly the home price of dairy products was higher in Australia, but, as Mr. Aird showed, the local consumption of dairy products forms a very small part of the total production of either country. A better idea of the comparative prices can be obtained from the export prices of butter. During 1925–34 the United Kingdom imported butter from the two countries as follows :

	Cwt.	£ (sterling).
New Zealand	17,006,811	104,656,687
Australia	12,142,132	69,043,139

(Source : Commonwealth Statistician.)

This gives an average price of 123/10 per cwt. for New Zealand and 113/9 for Australian butter. The figures for the former country are certainly not increased by taking a standard base price. In converting the average prices for the period 1925–34 from dollars to Australian pounds Mr. Aird should have used the average exchange rate for this period, and not that for 1934–35. This error has contributed to the discrepancy which he found between the standard prices and the prices in terms of the respective currencies.

The efficiency of New Zealand agriculture in the period to which the production figures relate (1934 and 1935) is shown by the statement of J. S. Ballantyne and Prof. S. M. Wadham (*Economic Record*, June, 1936, p. 45) : " The extent to which she (New Zealand) has endeavoured to meet difficult times by raising the efficiency of production, by organising and controlling her systems of marketing, by resolutely facing the need for the reduction of farmers' debts (secured or otherwise), by making it practicable to prevent the inefficient use of land and by the stimulation of scientific research, contrast sharply with the somewhat feeble efforts which have characterised the actions of some or all the Australian States in these matters."

Further illustration of the importance of adopting some standard price, in making international comparisons, is provided by the statement of Mr. Aird that in Norway " the number of cows that can be handled by one worker is probably half what it is in Australia ". By using the same price as a base this difference in productivity is shown : by using the local prices the difference would be distorted. Throughout Mr. Aird's article productivity seems to have been confused with other things, like relative prosperity and real incomes, which are affected by many other factors such as terms of trade, tariff policy, and rates of exchange.

Without any explanation, Mr. Aird states that living areas " should be closely correlated " with optimum areas. There does not seem to be any reason why this should happen to be so. This would assume that the most efficient size would just happen to be the size that provides

a normal family with a certain standard of living, and it would have to change with variations in the prices of the products.

The very important question of agricultural economics was raised. From a standpoint of national production, it seems desirable that the potential benefits arising from research and developments in agricultural science should not be wasted by a faulty economic approach. Though some economists may give quite a deal of attention to the agricultural aspects of economics, it would be disastrous for them to so narrow their attention that they did not keep abreast of developments in such closely related parts of economic theory as international trade, foreign exchange, imperfect competition, mortgage banking, and rent theory. Agricultural economics is in fact based on the same principles as any other part of economics, and the economist, without a knowledge of the technical details of agriculture, may be able to give some assistance to agricultural scientists. Similarly, it would be impossible, I suppose, for an agricultural scientist to keep up to date with all developments in his own field as well as in economic theory. There seems some danger in a " jack of all trades " approach to agricultural economics. Perhaps better results could be achieved by an application of the principle of the division of labour and cooperation between agricultural scientists and others, such as accountants, statisticians or economists. In South Australia and Western Australia, there has been, I understand, some cooperation between the official bodies of economists and agricultural scientists. The work achieved by Professors Wood and Wadham provides an excellent example of the benefit to be derived from such cooperation.

P. R. JUDD.

Canberra, A.C.T.,
30th December, 1941.

Obituary

ARTHUR H. K. PETRIE

Dr. Arthur H. K. Petrie, Plant Physiologist at the Waite Agricultural Research Institute, whose recent death at the early age of 38 we regret to announce, was born in Sydney. His father, Dr. James Petrie, was well known in scientific circles as Macleay Fellow of the Linnean Society of New South Wales in the field of plant biochemistry, a tradition which his son was later to take up in the field of plant physiology. Petrie graduated in the Botany School of Sydney University in 1925 and showed great promise as a research student. His main interests were then ecological and he was an important member of the team of workers which made a thorough study of the plant ecology of the rain forests of Mount Wilson.

In 1926 he joined the staff of the Botany School of Melbourne University, becoming assistant lecturer in 1929 and acting senior lecturer during 1930. During the period of his association with Melbourne he spent two years in Cambridge as 1851 research scholar and there developed the interest in plant physiology which he hoped to make his life's work.

In 1931 Petrie was invited by the Waite Institute to become plant physiologist in a team of workers which was devoting its attention to the study of mineral deficiencies in plants. Although his outlook at the outset was academic, his special knowledge of physiological principles was a valuable asset to the team and he was frequently consulted by other members of the staff on these matters. His work developed into a study of the growth and development of plants of agricultural importance, and of the chemical changes associated with this development. Of recent years he had been closely associated with the tobacco investigations of the C.S.I.R., making use of his special knowledge and outlook in an endeavour to discover the factors controlling the quality in Australian grown tobacco.

His work in this difficult field was nearing completion and although by varying experimental conditions he was able to produce quite important changes in the chemical composition of tobacco leaf, he was disappointed that these were not correlated with significant changes in quality. During the course of this work he had become more and more interested in the practical problems involved and had already formulated a programme of work which would have involved close cooperation with growers in these parts of Australia where tobacco is grown of acceptable quality. Petrie was never afraid to tackle difficult problems nor to speak his mind freely. His death is a loss to the world of both pure and applied botany.

J.A.P.

Personal Notes

Dr. A. R. Callaghan has been appointed chairman, and Mr. R. Hill a member, of the Crown Lands Development Committee in South Australia, charged with the examination of proposals for development of new land and the planning of settlement thereon other than for irrigation.

Messrs. K. Woodroffe, A. J. K. Walker, R. I. Herriot and B. E. Butler, of the South Australian Branch, are on R.A.A.F. Reserve. Lt. D. C. Riceman is with the E.M.U. Forces, abroad.

Mr. N. H. Shaw, of the A.C.T. Branch, has been seconded for six months from the Division of Plant Industry, C.S.I.R., to the Department of Labour and National Service, for factory survey work.

Mr. A. C. Smith has been re-appointed Cheese Expert of the Victorian Department of Agriculture. Mr. Smith agreed to submit himself for re-appointment to this position following an urgent appeal from the dairying industry of Victoria.

Enlistments of members of the Queensland Branch include D. O. Atherton, F. Chippendale, R. F. Langdon and L. F. Mandelson (A.I.F.); J. E. C. Aberdeen, J. H. Simmonds, J. A. Weddell and H. E. Young (A.M.F.).

Mr. A. B. Cashmore, Treasurer of the Western Australian Branch during the past two years, has become an officer in the R.A.A.F.

Dr. R. J. Noble has been appointed one of the Trustees of Taronga Park Zoological Gardens. Dr. H. J. Hynes has been seconded to the State War Effort Co-ordination Committee for special duties. Dr. C. J. P. Magee becomes Acting Chief Biologist.

Enlistments of members of the New South Wales Branch up to the end of last year include S. L. Allman, J. D. Bull, G. W. Clarke, P. A. Reid, H. R. Richardson, J. O. Smith, R. C. Wallace, A. G. Lowndes (A.I.F.); C. P. Glasscock, W. A. Horsley, D. S. Jones, M. V. O'Reilly (R.A.A.F.); R. G. Downing (A.M.F.).

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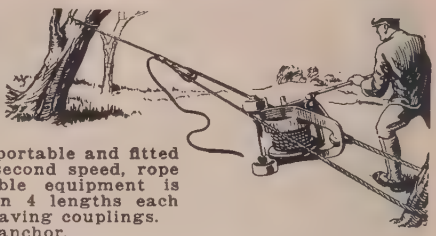

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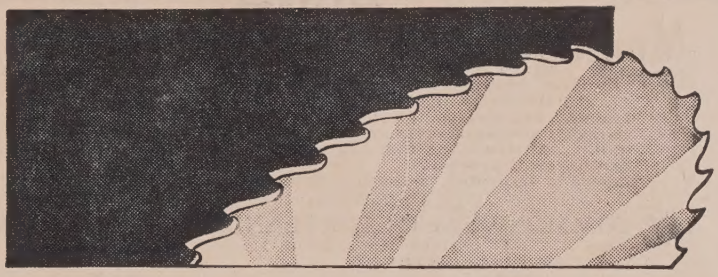

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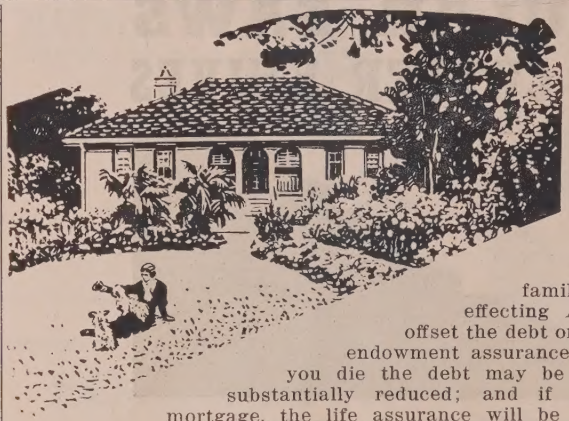

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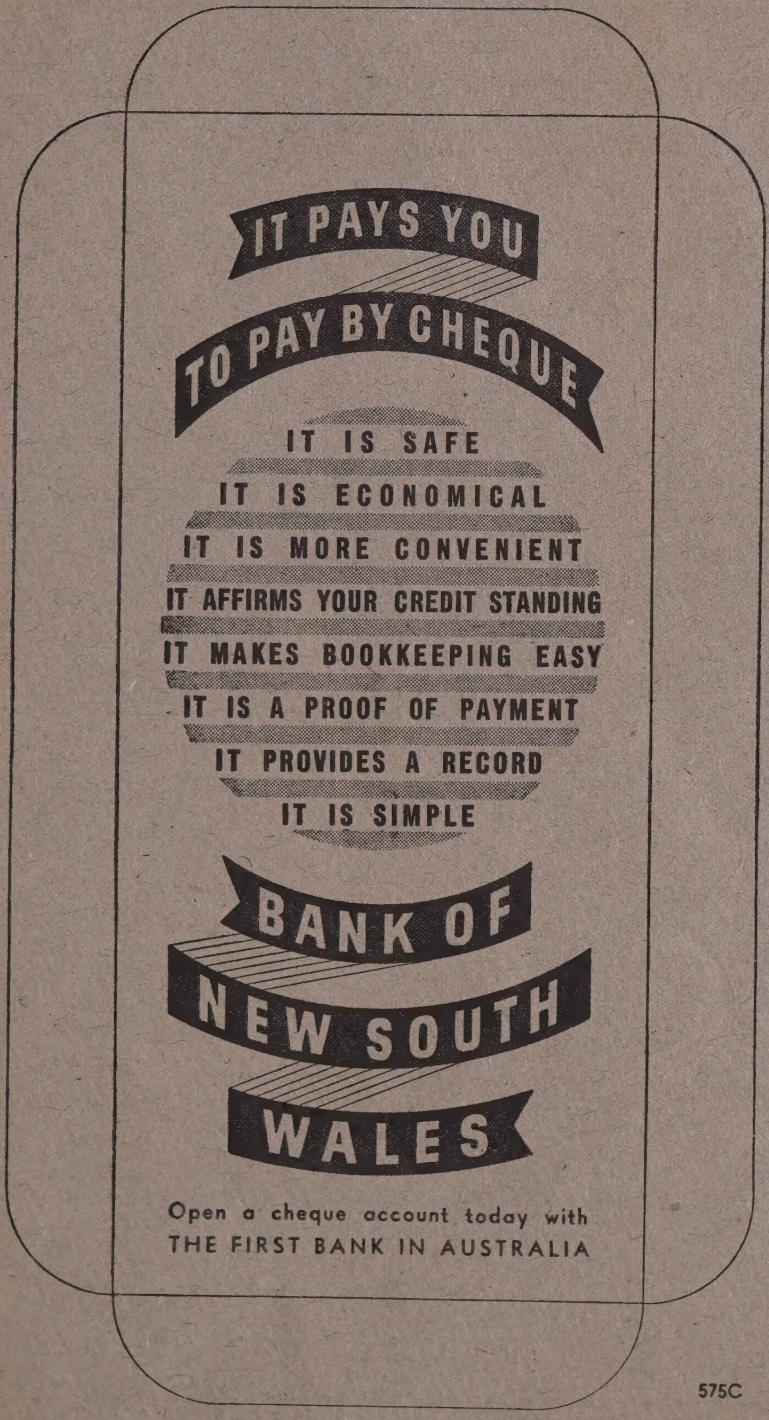
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